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APPLIED MECHANICS REVIEWS

VOL. 9, NO. 4 MARTIN GOLAND *Editor* APRIL 1956

COMBUSTION

HOWARD W. EMMONS

GORDON McKAY PROFESSOR OF MECHANICAL ENGINEERING, HARVARD UNIVERSITY, CAMBRIDGE, MASS.

ALTHOUGH the control and use of fire were one of the firsts by which man distinguished himself from the animals, it remains one of the little understood phenomena with which men work. Combustion of wood, coal, oil, and gas supplied almost all the power for man's progress through the ages and still supplies the major part of the vast power requirements of our modern civilization. How can it be possible that combustion is a "little understood" phenomenon? Let me explain what I mean by this by describing briefly some of the aspects of combustion that are known and some that remain a mystery.

The chemical nature of our major fuels is reasonably well deciphered. Even the spatial distribution of the carbon atoms in coal has been studied with some success. Certainly the chemical nature of the major products of combustion, water, and carbon dioxide is well known. The energy relations that apply when fuel and air become products of combustion are well known also, and detailed specifications of the heating value of fuels is a commonplace in industry. Many of the physical (as viscosity) and auxilliary chemical (as gumming) properties of fuels are also understood and controlled. The science of thermodynamics makes it possible to calculate with precision what the chemical composition of the partially dissociated products of combustion at high temperature will be and hence to take into account the exact final conditions (temperature for example) to be expected of a given process. But here our exact knowledge is about at an end and engineering progress is made largely through empirical data on the types and sizes of combustors already in use. Each new type or significantly different size of combustor must be developed by a long series of tests before satisfactory performance is obtained. To take a well-known example from the recent past, consider the combustion can of the jet engine. The weight, size, and performance requirements were unlike anything previously used and a great deal of cut-and-try development was necessary before the combustion was efficient, steady, and covered wide range, and the combustor had sufficient life.

Most of the serious gaps in our knowledge involve combinations of fluid mechanics, heat transfer, and chemical kinetics. Each of these fields alone has become understood in many but not all of its details. A new and radical type of airplane can be analyzed and its performance predicted with sufficient precision to make a first model flyable. A new heat exchanger designed by use of the dimensionless correlations of available experimental data can be built with confidence in its workability. A new size or type of combustion chamber can be expected to work properly on the first try only with the shearest of good luck.

Combustion problems involve, of course, the chemical reactions which convert reactants to products, but they also involve the processes by which the fuel and air are mixed, are ignited, are allowed to burn, and are guided through the chamber.

The mixing problems vary greatly depending upon the type of fuel and the space available. The contact between fuel and oxygen must be intimate indeed—ultimately atom to atom. For gaseous fuels, mixing means turbulence. But if pressure drop losses are to be kept small, it means just enough turbulence; too little gives incomplete combustion losses while too much costs pressure drop. For liquid fuels, mixing requires several steps. The first is the breakup of the liquid into small drops, usually by a jet of fuel. These drops are then evaporated, mixed with air, and burned. For solid fuels, oxygen must diffuse to the solid and products of combustion diffuse away while the fuel itself lies stationary in a bed (of coal) or flies as a particle of powdered fuel.

In each case—solid, liquid, gas—the qualitative description of the known phenomena and a statement of the status of our knowledge would be a suitable subject for another feature article like this one. The phenomena range all the way from the relatively (not absolutely) simple turbulent mixing of fuel and air jets to the burning of wood with its evaporation of excess moisture, its thermal decomposition, its jet and explosive release of gaseous combustibles, its production of smoke and charcoal. The pleasure derived from the contemplation of a wood fire by a combustion specialist is little different from that of the boy scout.

The ignition of a fuel air mixture requires a sufficient increase of the mixture temperature. Very crudely, a given fuel air mixture has an ignition temperature—a temperature above which active burning occurs and below which there is little reaction. I say "very crudely" because the attempt to make the concept quantitatively precise is met with failure because different experimental arrangements yield different results. Our knowledge of chemical rate processes shows that there is never a temperature below which nothing occurs. At all temperatures there is some finite reaction rate. Thus the presence of cold walls or chemically active walls greatly influences whether or not a mixture will ignite and burn. The exact chemical processes that occur during the ignition and burning of commercially important fuels is unknown. The theoretical calculation of the simplest of combustion processes—the rate of passage of a laminar flame front through a premixed gaseous fuel air mixture—is possible in only

very few cases because of a lack of knowledge of the detailed chemical steps, the reaction rate data on these chemical steps, and the physical data on the (generally) numerous chemical species present. The ignition that occurs to propagate the flame front involves conduction of heat and the diffusion of the various chemical species. The impossibility at present of the theoretical calculation of flame speed is an obvious consequence of our lack of knowledge of the chemical species present which, as I said above, is true for practically all commercially important cases.

The burning of the mixed and ignited fuel and air is usually simply a matter of giving the mixture enough time and enough space. About all that can go wrong with this part of the process is for the burning mixture to run into or slide against a cold wall or mixed with additional cold fluid which would "put the fire out." In practical cases the aforesaid simple statement is of little use, for what do you do when you are in a hurry and have little available space? Every commercial furnace or combustor has to be held to some reasonable size, although sometimes the pinch is worse than others. If it were possible to predict the exact way in which the burning mixture moved about inside of a combustor, the heat transfer to the walls could be better estimated and hence the resultant cooling of the mixture itself could be estimated. Incomplete burning and hence inefficient combustor operation are caused by incomplete combustion arising by incomplete mixing or premature cooling by the walls. The developments in aerodynamic theory which has done so much for airplane design has not yet gone far enough to predict the complex turbulent motions to be found in most combustion devices. It should be pointed out that laminar flows with combustion have not yet been computed with acceptable precision. Even the problem of the flow through a two-dimensional V-flame has not yet been solved because of the mathematical difficulties.

The engineer is accustomed to solving problems too difficult for present-day mathematics by use of dimensionless correlations of empirical data. In combustion processes, however, the number of dimensionless variables which exert an important influence on the flow-heat-transfer-combustion process is so large that scaling is, at present, impossible. Only in very elementary cases has it been possible to deduce the appropriate scaling laws.

Lest this article appears to strike too pessimistic a note, let me conclude by observing that at the present time a great deal of fundamental work on all phases of these problems is being done in many laboratories around the world, and it can be confidently predicted that the kind of knowledge that has been so effective in the aerodynamics of the airplane is about to bear fruit in the combustion field also.

Books Received for Review

BROMBACHER, W. G., AND LASHOF, T. W., Bibliography and index on dynamic pressure measurement, Washington, D. C., U. S. Dept. of Commerce, National Bureau of Standards Circular 558, Feb. 14, 1955, iv + 124 pp. $0.75 (paperbound).

DANIELS, F., AND DUFFIE, J. A., editors, Solar energy research, Madison, Wisconsin, University of Wisconsin Press, 1955, xv + 290 pp. $4.

DZUNG, L. S., AND ROHRBACH, W., editors, Enthalpie-Entropie-Diagramme für Wasserdampf und Wasser (im auftrag der AG Brown, Boveri & Cie, Baden, Schweiz), Berlin, Göttingen, Heidelberg, Springer-Verlag, 1955, vi + 17 pp. DM 7.50 (paperbound).

FIELLER, E. C., LEWIS, T., AND PEARSON, E. S., Correlated random normal deviates (Tracts for computers 26), New York, Cambridge University Press, 1955, xv + 60 pp. 10s.6d.

FIFTH SYMPOSIUM ON COMBUSTION; combustion in engines and combustion kinetics (held at the University of Pittsburgh, Pittsburgh, Pennsylvania, August 30–September 3, 1954), New York, Reinhold Publishing Corporation; London, Chapman & Hall, Ltd., 1955, xxiv + 802 pp. $15.

FRENKEL, J., Kinetic theory of liquids, New York, Dover Publications, Inc., 1955, xi + 488 pp. $1.95 (paperbound).

HILSENRATH, J., BECKETT, C. W., BENEDICT, W. S., FANO, L., HOGE, H. J., MASI, J. S., NUTTALL, R. L., TOULOUKIAN, Y. S., AND WOOLLEY, H. W., Tables of thermal properties of gases, Washington, D. C., U. S. Dept. of Commerce, National Bureau of Standards Circular 564, Nov. 1, 1955, ix + 488 pp. $3.75.

HUNTLEY, H. E., Dimensional analysis, New York, Rinehart & Company, Inc., 1955, ix + 158 pp. $3.50.

KAYS, W. M., AND LONDON, A. L., Compact heat exchangers. A summary of basic heat transfer and flow friction design data, Palo Alto, California, The National Press, 1955, xii + 156 pp. $5.

M. W. KELLOGG COMPANY, Design of piping systems, 2nd ed., New York, John Wiley & Sons, Inc.; London, Chapman & Hall, Ltd., 1956, xiv + 365 pp. $15.

PAI, S.-I., Fluid dynamics of jets, New York, Toronto, London, D. Van Nostrand Co., Inc., 1954, xv + 227 pp. $5.

PROCEEDINGS of the international conference on the peaceful uses of atomic energy, Geneva, August 8–20, 1955. Vol. 3, Power reactors, New York, United Nations, 1955, 389 pp. $7.50. (Columbia University Press.)

ROLFE, R. T., Steels for the user, 3rd ed., rev. and enl., New York, Philosophical Library, 1956, xvi + 399 pp. $10.

SHAPIRO, J. S., Principles of helicopter engineering, New York, McGraw-Hill Book Co., Inc., 1955, xiv + 433 pp. $12.50.

SOKOLNIKOFF, I. S., Mathematical theory of elasticity, 2nd ed., New York, Toronto, London, McGraw-Hill Book Co., Inc., 1956, xi + 476 pp. $9.50.

SPROULL, R. L., Modern physics, a textbook for engineers, New York, John Wiley & Sons, Inc.; London, Chapman & Hall, Ltd., 1956, xii + 491 pp. $7.75.

STRATTON, J. A., MORSE, P. M., CHU, L. J., LITTLE, J. D. C., AND CORBATÓ, F. J., Spheroidal wave functions (Technology Press Books in Science and Engineering), Cambridge, Mass., The Technology Press of M. I. T.; New York, John Wiley & Sons, Inc.; London, Chapman & Hall, Ltd., 1956, xiii + 613 pp. $12.50.

TABLE OF HYPERBOLIC SINES AND COSINES, Washington, D. C., U. S. Dept. of Commerce, National Bureau of Standards Applied Mathematics Series 45, Nov. 15, 1955, v + 81 pp. $0.55 (paperbound).

TABLES OF SINES AND COSINES OR RADIAN ARGUMENTS, Washington, D. C., U. S. Dept. of Commerce, National Bureau of Standards Applied Mathematics Series 43, Jan. 11, 1955, xi + 278 pp. $3.

ZIMMERMAN, O. T., AND LAVINE, I., Conversion factors and tables, 2nd ed., Dover, New Hampshire, Industrial Research Service, Inc., 1955, xxii + 501 pp.

Theoretical and Experimental Methods

(See also Revs. 989, 992, 996, 998, 1006, 1008, 1024, 1027, 1080, 1103, 1144, 1167, 1191, 1226, 1243, 1262, 1290)

968. **Washizu, K., On the bounds of eigenvalues,** *Quart. J. Mech. appl. Math.* **8,** 3, 311–325, Sept. 1955.

Generalization of Rayleigh's theorems for the bounds of eigenvalues for systems with finite degrees of freedom is presented. Paper is comprehensive in reviewing and developing previous approaches by several authors to the general problem of representation and bounding of generalized vector problems.

The generalized Rayleigh theorem is demonstrated to be suitable for several specific examples. Author claims it can be extended to systems with infinite degrees of freedom.

J. B. Duke, USA

969. **Hellman, O., Application of matrizant for the solution of eigenvalue problems** (in German), *ZAMM* **35,** 8, 300–315, Aug. 1955.

Author treats a linear homogeneous differential equation (or a group of such equations) with coefficients containing the independent variable and a parameter. This equation is to be satisfied together with linear homogeneous boundary conditions. The satisfaction of this differential system demands, as usual, that the parameter assume certain values; and it is these values that are to be determined. This is, of course, an eigenvalue problem.

Author adopts the known method of reducing the differential equation(s) to a system of linear homogeneous differential equations of the first order. This is then solved by the Picard-Lindelöf iteration procedure in matrix form (it is here that the so-called matrizant appears). When the solution is substituted into the matrix equation of the boundary conditions, a determinant is obtained, the vanishing of which determines the eigenvalues.

Reviewer finds the treatment elegant, but regrets to say that most of the material is already contained in a paper entitled "The boundary problems and developments associated with a system of ordinary linear differential equations of the first order" published in 1923 in the *Proc. American Academy of Arts and Sciences* by G. D. Birkhoff and R. E. Langer. In this celebrated paper, Birkhoff and Langer, after a thorough presentation of the general theory, focused their attention on the evaluation of, and the behavior of, the solution for large eigenvalues—a difficult problem which is very important for hydrodynamics because the eigenvalue (of the Reynolds number) involved in problems of hydrodynamic stability is usually very large. The contribution of the present paper consists, therefore, only in the emphasis on small eigenvalues (which are important in vibration problems) and in a few well-chosen examples given for the purpose of illustration.

C.-S. Yih, USA

970. **Kreyszig, E., Utilization of additional information for inclusion of eigenvalues in iteration** (in German), *ZAMM* **35,** 3, 89–95, Mar. 1955.

Given a Hermitian matrix A and an iterative sequence of vectors $x_0, x_1 = Ax_0, \ldots, x_s = A^s x_0$, it is shown that special information can be exploited for the inclusion of the eigenvalues of A, and that the accuracy can be increased by that way. The special information may concern, e.g., eigenvalue-free intervals, perhaps in the case of positive definite A, or bounds of certain eigenvalues.

From author's summary by L. Goland, USA

971. **Fox, L., A note on the numerical integration of first-order differential equations,** *Quart. J. appl. Math.* **7,** 367–378, 1954.

Author points out the difficulty of replacing a first-order differential equation by a suitable difference equation: If the difference equation is also of first order it lacks both symmetry and accuracy, and if it is symmetrical it is of second order and cannot be solved without one additional item of data. He then shows the advantages of replacing the first-order differential equation by an equivalent second-order differential equation with the first derivative eliminated. This leads to a simple second-order difference equation, which is generally a good representation of the differential equation, and which is readily solved either step-by-step or by relaxation.

Courtesy of Mathematical Reviews W. E. Milne, USA

972. **Schröder, J., Solution of potential problems with the aid of the difference method** (in German), *ZAMM* **34,** 7, 242–253, July 1954.

Paper concerns the approximate solution of the equation $\Delta U - cU + p = 0, c = \text{const}$, where Δ is the Laplacian. This equation, as usual, is replaced by difference equations on a lattice. It is shown how, by suitable numbering of the lattice points, the labor of the solution of the linear equations to which the method reduces may be greatly diminished. Two examples, one of which is a characteristic value problem, illustrate the method numerically.

L. M. Milne-Thomson, England

973. **Blanc, Ch., and Liniger, W., Stochastic error determination in numerical methods** (in German), *ZAMM* **35,** 4, 121–130, Apr. 1955.

General mathematical relations for errors caused by approximate, hence incomplete, numerical methods are given for prescribed quantities represented by a correlation function. Errors in Simpson, Newton-Cotes, and other methods are compared for assumed spectral distribution of prescribed quantity. The solution of linear boundary problems of second order by linear approximate and finite difference formulas are compared, showing the latter are superior to the former methods.

Y. Takahashi, USA

974. **Aparo, E., Numerical resolution of a problem of least squares** (in Italian), *Ric. sci.* **25,** 11, 3039–3044, Nov. 1955.

Description of a method of orthogonalization for the calculation, in second approximation, of the matrix reducing to a minimum a certain quadratic form and of the reciprocal matrix of a given one. The procedure has been tested on an electronic computer.

From author's summary

975. **Morduchow, M., Method of averages and its comparison with the method of least squares,** *J. appl. Phys.* **25,** 10, 1260–1263, Oct. 1954.

It is shown, under fairly general conditions, that the standard deviation of the residuals of the straight line fitting a set of points with uniformly spaced abscissas by the method of averages is, at most, $2/3^{1/2}$ times as great as the standard deviation of the least-squares line. Theorems of significance in the practical use of the method of averages are proved in the course of the analysis.

From author's summary

976. **Saltzer, C., An abridged block method for the solution of the Dirichlet problem for the Laplace difference equation,** *J. Math. Phys.* **32,** 63–67, 1953.

The method presented is based upon the use of the explicit formula for the solution of the Dirichlet problem for the Laplace difference equation for a rectangular region. The procedure can be applied to any net which can be decomposed into a finite number of abutting or overlapping rectangles, and any finite net can be decomposed in such a way. The advantage of the method is

that the number of equations which arise in the usual procedure is, in general, considerably reduced, and in some cases the number becomes so small that the system of equations can be solved directly. Consider the simplest case, that of two abutting rectangles L and R, and the Dirichlet difference boundary-value problem for the region $L + R$. Clearly, once the values of the solution have been determined for the common boundary points of L and R, which are interior points of $L + R$, the solution of the Dirichlet problem for $L + R$ is then reduced to the solution of separate Dirichlet problems for L and R, which can be solved by means of the explicit solution formula for a rectangular region. Using this explicit formula for a rectangular region, and the fact that the Laplace difference equation must hold at each common boundary point of L and R which is an interior point of $L + R$, author obtains a system of linear equations for the unknown values of the solution at these points, from which these values can be directly calculated first, in terms of the given Dirichlet data. This method is the finite-difference analog of the method of *B.* Epstein [*Quart. appl. Math.* **6**, 301–317, 1948; see AMR **2**, Rev. 329] for the continuous case. The procedure can be easily extended to higher dimensions and more complicated meshes.
Courtesy of Mathematical Reviews J. B. Diaz, USA

977. Duncan, W. J., Note on test functions for stability, *Quart. J. Mech. appl. Math.* **8**, part I, 30–37, Mar. 1955.

Interesting relations are presented between test functions (Hurwitz determinants) for determining the stability of roots or characteristic equation of a linear system. In particular, it is shown that the critical (penultimate) test determinant for any equation of even degree can be expressed in terms of that of a quartic. Also, when absence of certain coupling terms enables factoring of characteristic equation, the critical test determinant contains an irrevelant factor. A. A. Schy, USA

978. Johnson, E. F., ed., Analogs as aids in process studies, 4 papers, *Indust. Engng. Chem.* **47**, 3 (part I), 396–421, Mar. 1955.

The following four papers were presented at a symposium sponsored by the Division of Industrial and Engineering Chemistry at the 126th Meeting of the American Chemical Society, New York, N. Y. An introduction was given by E. F. Johnson which presents the distinguishing characteristics between the model or analog and its prototype. Emphasis is given to the use of process analogs as a convenient and rapid means of studying a variety of plant processes. The following four papers of this symposium describe electrical, hydraulic, and pneumatic analogs in the analysis of various unit operations and their controls.

Design analysis of linear hydraulic analog by R. H. Hass and P. J. Sauer. This paper describes a liquid level analog that was designed and constructed as a visual aid in teaching elementary instrumentation and process control to students. The process consisted of water flowing through two open weir tanks arranged in cascade. The rate of flow to the upper tank and the liquid level of the lower tank were measured and controlled by an electronic proportional-reset rate-derivative time-recording controller. Transient response characteristics of the process were calculated and presented with experimental results.

Applications of pneumatic analog by E. F. Johnson and T. Bay. In studying process-control theory it is advantageous to use a simple analog which behaves like commercial processes. The pneumatic analog used in this work consists of an array of volume chambers connected by fine bore tubing dead-ended at a conventional pneumatic recording controller, which feeds air to the volume chambers through a null-balance pressure regulator. Experimental frequency-response characteristics of a three-stage process are compared with characteristics predicted from the system geometry and flow equations. Three different methods for predicting desirable control settings for proportional and proportional plus reset control are applied to the process, using both frequency and transient-response data. The particular advantages and the practical limitations of pneumatic analogs are discussed and compared with other types, such as hydraulic and electrical analogs.

Signal flow diagrams for process evaluation by D. P. Campbell. The concept of signal flow diagrams is developed as a powerful tool for devising analogs related to process regulation. They are basically block diagrams where the mathematical operations assigned to the various blocks are derived from the physics of the unit processes. The manner of interconnecting these groups of blocks establishes not only the nature of a unit process but also the precision of control and regulation that may be expected for the particular unit process, as well as stability of the system in which it is used.

Analysis of unsteady fluid flow using direct electrical analogs by S. E. Isakoff. A review is given of the direct analogy between pressure and flow fluctuations in fluid systems, and voltage and current oscillations in electrical networks. A comparison is given of the results from experimental studies of pulsation dampers located at the discharge of a reciprocating compressor with the results from equivalent electric networks. Examples are cited of use of electrical analogs in the analysis of factors affecting the tendency of a system to oscillate, in development of frequency-response data to aid in instrumentation and control, in study of pressure transmission, and as an aid in determining fluid meter requirements. J. Aronofsky, USA

979. Zsolt, N., Analog computer for the solution of linear systems of equations (in Hungarian), *Magyar Tud. Akad. Mat. Fiz. Oszt. Közl.* **3**, 2, 157–169, 1955.

A set of linear algebraic equations is solved by iterative method using an electrical device. A series of interconnected transformers and variometers is constructed to solve one equation at a time. G. Kron, USA

980. Wilkinson, J. H., An assessment of the system of optimum coding used on the pilot automatic computing engine at the Natural Physical Laboratory, *Phil. Trans. roy. Soc. Lond.* (*A*) **248**, 946, 253–281, Oct. 1955.

981. Haneman, V. S., and Senders, J. W., Correlation computation on analog devices, *J. Assn. Comp. Machy.* **2**, 4, 267–279, Oct. 1955.

A survey of correlation computers, methods of application, and problems associated with this type of equipment has been conducted. The results of this survey are presented in the hope that it will stimulate thinking to improve the methods of application and computation, to reduce duplication of effort, and to promote a flow of information on correlation computation.
From authors' summary

982. Pebay-Peyroula, J. C., and Simon, P., Development of a direct-reading electronic calculator for correlation analysis (in French), *J. Phys. Radium* **15**, Supp. to no. 5 (Phys. appl.), 101–108, May 1954.

A device is described by which graphical data can be read mechanically and the correlation between two such curves or between points on the same curve separated by a time interval can be read directly. The paper defines the correlation coefficients which the device calculates. It describes in detail the reading device and the electronic circuit by means of which the correlation coefficient is established. By comparison with simple functions, the accuracy of determination of the correlation coefficient is es-

tablished. A limitation of the use of the device is that the graphical records must be made of paper having no other marking and that they must be in black ink $^1/_2$ mm wide.

M. A. Mayers, USA

983. **Svensson, J., A new formula for particle size distribution of products produced by comminution,** *Trans. roy. Inst. Technol. Stockholm* no. 88, 3–19, 1955.

Author presents a general function expressing the particle size distribution for products of comminution. The expression covers a greater range of particle size distribution than the earlier relationships proposed by Gaudin and Rosin-Rammler. Application of the general relationship is made to products of comminution reported in the literature as well as to those produced by the author. The relationship appears most applicable to the size distributions selected. The formula and extensive tables, which are included for ease in evaluation, seem to be directly applicable to the calibration of testing sieves.

The general function appears to have serious limitations when used to predict the particle size distribution in the products from various types of comminution machinery in which the products may be subjected to sieving action or when used for loose-grained material.

L. Farbar, USA

984. **Shannon, C. E., Game playing machines,** *J. Franklin Inst.* 260, 6, 447–453, Dec. 1955.

985. **Hrenov, L. S., Five-place tables of the trigonometric functions with argument expressed in hourly measure [Pyatiznačnye tablicy trigonometričeskih funkcii s argumentom, vyražennym v časovoĭ mere], 2nd ed.,** Moscow, Gos. Izdat. Tekh.-Teor. Lit., 1954, 172 pp. 7.70 rubles.

The main table gives values of the six trigonometrical functions at interval of 4 seconds of time (i.e., 1 minute of arc), usually to 5S, in the range 0 to 3 hours. (Whenever the leading figure is unity, five further digits are given). First differences are usually given, with their proportional parts alongside the tables. An auxiliary table, new in this second edition, gives cot x, cosec x to 5S for $x = 0(.1^s)08^m(1^s)40^m$. There is a table of $\sin^2(^1/_2x)$ for $x = 0(4^s)12^h$. Entries with terminal 5 are marked with ± to indicate in what direction rounding should be made. There is a collection of conversion tables, constants, and formulas from plane and spherical trigonometry, and there are worked examples showing the direct and inverse use of the tables. The tables are clearly printed.

There are no references to sources, nor is there a description of the construction. It is stated that the entries are correct to half a unit in last place. The tables should be convenient for those who require something between the two volumes issued by L. J. Comrie ["Four-figure tables . . . argument in time," London, 1931] which gives 4+ decimals at 10^s interval, and the British Nautical Almanac Office ["Seven-figure trigonometrical tables for every second of time," H. M. Stationery Office, London, 1939], which gives values to 7D at 1^s interval.

Courtesy of Mathematical Reviews J. Todd, USA

986. **Sibagaki, W., 0.01% tables of modified Bessel functions, with the account of the methods used in the calculation** (title pages in Japanese and English), Tokyo, Baifukan, 1955, xxi + 130 pp. 1050 yen.

This handy book tabulates the modified Bessel functions $x^{1/2}I_n(x)$ and $x^{1/2}K_n(x)$, $n = 0(1)22$ for I_n and 23 for K_n, $x = 0(.01)1(.02)5(.04)25$, to 4 or 5 significant figures, with differences corresponding to the increment $\Delta x = 0.01$. This table is an improved version of an earlier mimeographed 1945 edition [see *Math. Tables Aids Compt.* 5, 80, 1951] and differs from its predecessor in tabulating $x^{1/2}I_n(x)$ and $x^{1/2}K_n(x)$ instead of $I_n(x)$ and $K_n(x)$ for $x \leqq 5$. This new edition contains much more introductory material: a section on the description, use, and preparation of the tables is in both English and Japanese; the later sections, in Japanese only, deal with the following topics: properties of the modified Bessel functions, derivation of Debye's asymptotic formulas by steepest descent, and a description of a method of numerical integration of ordinary differential equations of the form $y'' = f(x, y)$ with two long examples illustrating the special case of $f(x, y) = (1 + x^{-2}(n^2 - 1/4))y$. Graphs of both $x^{1/2}I_n(x)$ and $x^{1/2}K_n(x)$ are provided. A short critical table of Bessel's second-order coefficient at the end aids in quadratic interpolation, sufficient nearly everywhere. The printing, paper, and hard-cover binding also present great improvements over the earlier version. There is a short list of errata on an insert.

Courtesy of Mathematical Reviews H. E. Salzer, USA

987. **Herz, C. S., Bessel functions of matrix argument,** *Ann. Math. Princeton* (2) 61, 474–523, 1955.

"In this work we generalize the classical special functions of hypergeometric type . . . . Particular stress is laid on a generalized Bessel function . . . which is a complex-valued function having for argument a complex $m \times n$ symmetric matrix . . . . First, a large number of formulas from the classical theory of special functions are given appropriate generalizations. Some of these turn out to have applications to lattice-point problems and to the theory of non-central Wishart distributions in statistics. Secondly, the L^2-theory of the Hankel transform is established with the generalized Bessel functions furnishing the kernel . . . . The third class of results concerns the properties of harmonic polynomials in several variables . . . . They are related . . . to generalized Gegenbauer polynomials . . ." (From the author's Introduction.)

The principal tool in the author's investigations is the Laplace transform whose kernel is exp [−trace (ΛZ)], integration being extended over the set of all positive definite matrixes Λ. If the integral converges in some "right half-plane," i.e., if Re $Z - X_0$ is positive definite for some X_0, then the Laplace transform is an analytical function of the symmetric matrix Z. Starting with ${}_0F_0(\Lambda) = \exp(\text{trace } \Lambda)$, all generalized hypergeometric functions may be generated by a succession of Laplace transformations and inverse Laplace transformations.

Courtesy of Mathematical Reviews A. Erdelyi, USA

Mechanics (Dynamics, Statics, Kinematics)

(See also Revs. 1184, 1322, 1323, 1326)

988. **Beggs, J. S., Mechanism,** New York, McGraw-Hill Book Co., Inc., 1955, xiii + 418 pp. $6.50.

Book is intended for graduate students and practicing engineers. In kinematics and dynamics, author uses graphs and vectors for finding positions, velocities, and accelerations in two and three dimensions. There is a brief discussion of fundamentals of gears, tooth shapes, and cams, but application and design of gear trains are very thorough. Unusual gearing, particularly of modern developments, is considered. Chapter on rotary drives includes universal joints, variable speed drives, hydraulic drives, couplings, clutches, brakes, and intermittent drives. Tension and flexural members (belts, cables, chains, torsion bars, springs, diaphragms, Bourdon tubes, brushes, elastomers, bellows, fastenings, shock mounts) and compression members (hydraulic and pneumatic devices) as links are a refreshing and important viewpoint.

Mechanical computing devices discussed are integrators, resolvers, differentials, multipliers, and parts of desk calculator. There are unusual chapters on electric, hydraulic, and pneumatic controls, switches and relays; kinematic design for precision and accuracy; a repertory of names and sketches of useful, ingenious, and novel mechanisms; a digest of patent law, a glossary, and a large bibliography.

Designers will find the book a fruitful reference work.

M. Goldberg, USA

989. Bereis, R., On the envelopes of straight lines, fixed in a plate, which moves in its plane (in German), *Öst. Ing.-Arch.* **9**, 1, 44–55, 1955.

This is a continuation of author's papers [AMR **4**, Rev. 4376; and **6**, Ref. 2421], but as time does not occur at all in this third paper, it is purely geometrical. No engineering applications are mentioned. Some beautiful statements are found on the circles of regression, on the curvature centers of higher order, on the affine normals, and on the osculating conic sections of the envelopes in question.

H. O. Faxén, Sweden

990. Kloomok, M., and Muffley, R. V., Plate cam design—radius of curvature, *Prod. Engng.* **26**, 9, 186–192, Sept. 1955.

This is the third of a series of articles [title source, Feb. 1955 and May 1955] on plate cam design and it gives a comprehensive study of the radii of curvature of the cam profile and its follower. The authors not only give practical methods for computing these radii, but facilitate the task of the designer by supplying him with charts which were developed with the aid of automatic computing equipment. These charts are for cycloidal, harmonic, and polynominal motions and nondimensional. The derivations of the formulas are simple and easy to follow by the average designer who is familiar with the elements of differentiation.

M. Maletz, USA

991. Milwitzky, B., Lindquist, D. C., and Potter, D. M., An experimental investigation of wheel spin-up drag loads, *NACA TN* 3246, Sept. 1954.

A very much needed set of data on ground reaction on the wheel undercarriage by vertical impact with forward speed. The friction coefficient tire-ground decreases with increasing skidding velocity from 0.9 at 5 mph to 0.7 at 50 mph, and 0.3 at 150 mph. The reduction of drag load due to wheel prerotation is consequently diminished. The vertical load increases substantially with increasing drag load because of increased friction in the shock strut.

C. Riparbelli, USA

992. Bautin, N. N., The dynamical theory of clock movements without discontinuous stopping of the escape wheel (in Russian), *Inzhener. Sbornik* **21**, 3–31, 1955.

Mathematically speaking, the scheme gives rise to a pair of sets of linear differential equations with constant coefficients with passage from one set to the other across a point of discontinuity. Its discussion turns upon the study of a linear mapping of a three space of initial values into itself. The resulting formulas, including those for stability, are far too complicated and too technical to warrant description. [See earlier notes on this topic: Bautin, *Dokladi Akad. Nauk SSSR (N.S.)* **61**, 1, 1948 and **65**, 3, 1949, see AMR 3, Rev. 423; also Andronov and Naimark, ibid. **51**, 1, 1946].

S. Lefschetz, USA

993. Fisher, F. G., and Allen, R. K., Adhesion—How Much? ASME Ann. Meet., Chicago, Ill., Nov. 13–18, 1955. Pap. 55—A-132, 14 pp., 1955.

Wheel-to-rail adhesion is fundamental to the operation of a railroad. The potentially high tractive effort of modern diesel-electric and electric locomotives has focused attention more sharply on conditions which limit adhesion. Train stalls, rail burns, flat wheels, and damaged electric traction equipment all point to the importance of the problem. Extensive tests have yielded much information on the causes of low adhesion and methods of improving it. The results indicate that running adhesions in excess of 26% can be maintained by the application of certain materials to locomotive drivers or to the rail.

From authors' summary

994. Whitton, P. W., and Ford, H., Surface friction and lubrication in cold strip rolling, *Instn. mech. Engrs. Proc.* **169**, 5, 123–140, 1955.

See AMR **8**, Rev. 2232.

Servomechanisms, Governors, Gyroscopics

(See also Revs. 1128, 1210)

995. Silva, L. M., Predictor control optimalizes control-system performance, *Trans. ASME* **77**, 8, 1317–1323, Nov. 1955.

Paper concerns the control of systems in which it is desired to apply maximum corrective action during transients. It treats a compromise in which, after a step disturbance maximum corrective action is applied in the direction of decreasing the error, maximum corrective action is then applied in the other direction, and, finally, ordinary control involving a proportional term brings the system to equilibrium.

R. Oldenburger, USA

996. Kurakin, K. I., On the choice of the optimum characteristics of linear differentiators in automatic control systems (in Russian), *Avtomatika i Telemekhanika* **16**, 3, 293–299, 1955 (translated from Russian by M. D. Friedman, 572 California St., Newtonville, Mass. 10 pp.).

Wiener's method based on minimum mean-square error criterion is used in obtaining optimum transfer function of an element designed to produce either the derivative of the input function or both the derivative and the input itself. The input is accompanied by random noise with constant spectral density. The input is assumed to be a stationary random function such that, in each of the intervals bounded by randomly distributed points, its derivative either is a constant or approaches a certain value with a fixed time constant. In each case, the result takes on the form of a rational fraction with respect to the differential operator p. It is noted that the result is p times the transfer function of the optimum smoother.

S. Moriguti, Japan

997. Eggleston, J. M., and Mathews, C. W., Application of several methods for determining transfer functions and frequency response of aircraft from flight data, *NACA Rep.* 1204, 24 pp., 1954.

See AMR **7**, Rev. 565.

998. Hahn, W., Stability investigations in the recent USSR literature (in German), *Regelungstech.* **3**, 9, 229–231, 1955.

999. Brockett, G. F., and Kennedy, W. J. L., Effects of adjacent piping configurations on control-valve characteristics and capacity, ASME Ann. Meet., Chicago, Ill., Nov. 13–18, 1955. Pap. 55—A-138, 5 pp. + 15 figs., 1955.

1000. Washburn, W. D., and Milham, R., Terminology of process control valves, ASME Ann. Meet., Chicago, Ill., Nov. 13–18. Pap. 55—A-91, 19 pp., 1955.

1001. **Kirchner, F., Simple resonance experiments on symmetrical gyroscopes** (in German), *ZAMP* **6**, 5, 355–361, 1955.

A heavy symmetrical gyroscope, rotating with constant angular velocity about its axis of symmetry, is supported by cardan in a point of its axis which is not the center of gravity. External linear or elliptical sinusoidal periodic forces acting in horizontal direction on the gyroscope produce forced oscillations. Two resonances exist: one with the frequency of the precession, the other with that of the nutation of the gyroscope. An elementary calculation of the two frequencies is given. The purpose of the experiments is to find a model for the phenomenon of nuclear induction. L. Föppl, Germany

1002. **Wiebelitz, R., Theory of forced vibration of the symmetrical gyroscope** (in German), *ZAMP* **6**, 5, 362–377, 1955.

Referring to experiments carried out by F. Kirchner (see preceding review), author supplies a theoretical treatment of the forced vibrations (resonance) of a symmetric gyroscope acted upon by a constant moment M_1 and a periodic moment M_2. For a high-speed gyroscope, the problem, which arises in astronomy as well as in nuclear physics, has been treated by W. Braunbek [AMR **7**, Rev. 403] under somewhat more restricted assumptions. Author's principal results are valid for gyroscopes of arbitrary speed but restricted to small angles. For a circularly polarized moment M_2, an exact solution is obtained. For the remaining cases, Braunbek's method is improved. Nonlinear treatment yields subharmonic resonance. H. Ziegler, Switzerland

1003. **Chatterton, J. B., Some general comparisons between the vibratory and conventional rate gyro,** *J. aero. Sci.* **22**, 9, 633–638, Sept. 1955.

The vibratory rate gyro is compared analytically to the elastically restrained rate gyro for an assumed configuration of each. As a result of transfer function and error analyses, it is concluded that vibratory rate gyro has certain theoretical advantages for assumed configurations. Reviewer agrees that vibratory gyro shows large susceptibility to future development.

L. Becker, USA

Vibrations, Balancing

(See also Revs. 969, 1003, 1022, 1317)

1004. **Bishop, R. E. D., The treatment of damping forces in vibration theory,** *J. roy. aero. Soc.* **59**, 11, 738–742, Nov. 1955.

Paper defines "hysteretic" damping as identical with structural damping used in aircraft flutter work. Equations are presented for free and forced vibrations of a single-degree-of-freedom system; but no new physical interpretation is introduced, which, in the reviewer's opinion, is the most interesting part of the problem, particularly for the case of free vibration.

N. O. Myklestad, USA

1005. **Kauderer, H., Analysis of damping in free vibration** (in German), *Ing.-Arch.* **22**, 4, 251–257, 1954.

Paper shows the possibility of determining particular components of damping from measured amplitudes of a free vibrating system with one degree of freedom under the assumption that damping is relatively small and can be expressed in terms of power series with the velocity of the vibrating system as the variable. Constant coefficients of this series are the object of the solution.

By means of a method for solving nonlinear differential equations introduced by Kryloff and Bogoliuboff, relations between differences of adjoining amplitudes and related coefficients are derived.

Using either Newton or Lagrange interpolation formulas or the method of minimal squares, these coefficients can be computed.

As a practical example, analysis of forces damping the motion of a free pendulum is carried out.

Paper is a valuable contribution for the analysis of damping forces acting on vibrating mechanical systems, and the results obtained can be transferred to other analogical vibrating circuits.

V. Kopřiva, Czechoslovakia

1006. **Miscenko, E. F., and Pontryagin, L. S., Periodic solutions of systems of differential equations near to discontinuous ones** (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **102**, 889–891, 1955.

The system under discussion is

$$\epsilon\dot{x} = f(x, y), \qquad \dot{y} = g(x, y) \qquad [1]$$

where x and y are a p- and a g-sector and ϵ is small. Let the system

$$f = 0, \qquad y = g \qquad [2]$$

have a "discontinuous" periodic solution γ of a type familiar in investigations of van der Pol's equation. The authors determine the periodic solutions of [1] close $0(\epsilon)$ to γ and calculate their period. The qualitative analysis of the situation has already been made by Jelestsov and Rodygin [title source, **81**, p. 391, 1951]. An analogous determination for van der Pol's equation was already established by Dorodnytsin [*Prikl. Mat. Mekh.* **11**, p. 313, 1947].

Reviewer notes that the authors are not aware of a number of related "western" contributions, the most notable being the work of Jules Haag. See his 2 volumes: "Les mouvements vibratoires," Paris, Presses Universitaires de France, 1952–1955.

S. Lefschetz, USA

1007. **Sakurai, A., On extraordinary phenomena in a nonlinear forced oscillation,** *J. phys. Soc. Japan* **10**, 274–278, 1955.

The equation $\ddot{x} - dF(x)/dx = p \cos(\omega t)$ is analyzed by replacing it by a variation principle and inserting a Fourier expansion of period $2\pi/\omega$ for x. Equations for the coefficients are determined by a Rayleigh-Ritz technique. Approximations are made, but not justified, to simplify this system. An infinite determinant is constructed to whose roots correspond resonant frequencies. It is noted that the Fourier coefficients are generally real, but may become complex with a change of phase at resonance. It is remarked that the solution may become discontinuous as resonance is passed through, but details are not given. The theory is applied to a simple electrical circuit containing an iron-core inductor.

Courtesy of Mathematical Reviews E. Pinney, USA

1008. **Fuhrke, H., Determination of beam vibration with the help of matrix calculation** (in German), *Ing.-Arch.* **23**, 5, 329–348, 1955.

Determination of higher modes of vibrations requires a close approximation of actual system. A beam consisting of different fields, each field being homogeneous, is subjected to author's analysis. At the end points of such a field, author defines a column vector with components: deflection, slope, bending moment, and shear force. The vector at one end point of a field is obtained from the vector at the other end point by multiplication with matrix of the field. Components of field matrix are computed from geometrical and elastic quantities, mass, and eigenfrequency. Author includes effects of shear and rotational inertia. A section of beam consisting of several fields is replaced in analysis by matrix obtained by multiplication of all individual field matrixes

for that section. Restraints between end points are also represented by matrixes. Finally, relation between vectors at end points of the whole beam results in single equation determining unknown frequency. Common end restraints—clamped, simply supported, free—result in the determinant of second degree, elements of which are certain elements of the matrix. Author shows how to compute that determinant from those of individual matrixes. Method simplifies computation and increases accuracy, avoiding a resulting difference between two almost equally great numbers.

Forced vibrations are also treated. Paper includes a numerical example.

Reviewer finds method clear and elegant. However, tiresome numerical computations cannot be avoided since, except for simplest cases, computations have to be performed for different assumed values of eigenfrequency in a trial-and-error fashion.

F. I. Niordson, Sweden

1009. Kushul', M. Ya., and Shliakhtin, A. V., Theory of vibrational loading of cylindrical bars in elastic and plastic media (in Russian), *Izv. Akad. Nauk SSSR Otd. tekh. Nauk* no. 1, 92–104, Jan. 1954.

1010. McFadden, J. A., Radial vibrations of thick-walled hollow cylinders, *J. acoust. Soc. Amer.* **26,** 5, 714–715, Sept. 1954.

Author discusses free radial vibrations of a thick-walled cylinder. The modes are divided into two classes: "extensional," in which the mean radius varies but the thickness remains approximately constant; and "thickness modes," in which the mean radius is approximately constant and the thickness varies. Approximate results are given for wave lengths of these modes. The validity of the approximations is not made evident by a comparison with exact numerical solutions. The results given are probably of use as a starting point for more exact numerical calculations of normal mode frequencies.

J. M. Jackson, Scotland

1011. Reissner, E., On transverse vibrations of thin, shallow elastic shells, *Quart. appl. Math.* **13,** 2, 169–176, July 1955.

Author had previously shown [*J. Boston Soc. civ. Engrs.*, Apr. 1955] that the differential equations of the theory of shallow shells as formulated by Marguerre could be expressed as a system of two simultaneous equations for an Airy stress function F and the transverse displacement w. He notes that this system may be extended to include vibratory motion if, retaining only the transverse inertia term, the longitudinal inertia terms are neglected. In order to justify the omission of these terms, author carries out an order-of-magnitude analysis whereby he establishes the conditions for the validity of these simplified equations. To illustrate his results, author determines the frequencies of transverse vibrations of a paraboloidal shell with a simply supported rectangular boundary. C. N. DeSilva, USA

1012. Reissner, E., On axi-symmetrical vibrations of shallow spherical shells, *Quart. appl. Math.* **13,** 3, 279–290, Oct. 1955.

The two simultaneous equations of author's previous paper (see preceding review) are further simplified when the shallow shell is spherical. When the vibrations are axisymmetric, the integration of these equations is identical with that given previously by the author [*J. Math. Phys.* **25,** 80–85, 279–300, 1945]. Three specific problems are solved: (1) free vibrations, damped edge; (2) free vibrations, free edge; and (3) forced vibrations due to a point load at the apex, which entails determining the point force singularity independent of the boundary conditions.

C. N. DeSilva, USA

1013. Teresnov, S. A., On the eigenvalues and eigenfunctions of the oscillations of cylindrical shells (in Russian), *Soobshch. Akad. Nauk Gruzin. SSR* **15,** 9, 575–581, 1954 (translated from Russian by M. D. Friedman, 572 California St., Newtonville, Mass. 9 pp.).

Proof is given of existence of eigenvalues and eigenfunctions for differential equations of natural vibration of cylindrical shells. Paper is highly mathematical and should be of interest primarily to mathematicians. J. M. Hedgepeth, USA

1014. Falk, S., Reduction of a general vibrating system to the simple vibrating shaft (in German), *Ing.-Arch.* **23,** 5, 314–328, 1955.

Torsional vibrations of multimass branched systems without damping are analyzed. The kinetic and potential energies are expressed by the flexibility and inertia matrixes; then, by a suitable linear transformation of coordinates, the original system is reduced to, or mapped onto an equivalent "in-line" shaft, for which the natural frequencies are computed.

Two examples illustrate the use of these methods and also a graphical string polygon construction of modes of vibrations.

W. Ornstein, USA

1015. Pestel, E., Derivation and proof of the Baranow-Schaefer method for the determination of the frequencies and natural modes of vibrating shafts (in German), *Forsch. Geb. Ing.-Wes.* **21,** 5, 154–158, 1955.

A proof is given of the method to determine the frequency and vibrational mode of the natural frequencies of multiple-degree-of-freedom systems graphically by means of a reduction method. As a practical example, the problem of a shaft with four disks is treated in more detail. R. G. Boiten, Holland

1016. Hoschl, C., Unbalance in multicylinder internal combustion engines and torsional crankshaft vibrations (in German), *Maschinenbau-Technik* **4,** 6, 327–332, June 1955.

Torsional crankshaft vibrations result in unbalanced forces and moments throughout an engine mechanism and on the frame. At high speeds, these may be important even if the engine is balanced dynamically. Paper derives the relations between the torsional vibration amplitudes at the crank and the corresponding forces and moments. A numerical example is given for an 8-cylinder in-line 375-rpm diesel engine with prescribed torsional vibration amplitudes. G. A. Nothmann, USA

1017. Bolotin, V. V., Bending vibrations of shafts with cross sections of unequal principal rigidities (in Russian), *Inzhener. Sbornik*, **19,** 37–54, 1954.

In this paper, the problem of lateral vibrations of shafts with cross sections of unequal principal rigidities is treated by methods of nonlinear mechanics. The system considered by the author is a disk mounted on the middle of a horizontal shaft running in two bearings and vibrating in a vertical plane. It is assumed that the mass of the shaft can be neglected and that the disk has a certain eccentricity. Starting with the linear treatment of the problem, author gives some results concerning the limits of the critical regions and the forced vibrations of the system under the action of the weight and the centrifugal force.

In the nonlinear treatment of the problem the system is considered as having an infinite number of degrees of freedom, and it is assumed that at one end of the shaft there is an elastic constraint allowing horizontal displacements of the end of the shaft; the horizontal displacements are affected by the viscous friction in the bearing. The nonlinear equation of the problem is investigated in order to determine the amplitudes of lateral vibrations

of the system when the angular velocity has values which are nearly equal to ω/k, where ω is the frequency of natural vibrations in the sense of Galerkin's method, and $k = 1, 2, 3, \ldots$.
J. Beranek, Czechoslovakia

1018. **Gorskaya, N. S., Equations of motion of a pneumatic drive** (in Russian), Collection of works on automatics and telemechanics, 1953; transactions of the first conference on automatics and telemechanics held in 1951 by the young specialists of the Institute of Automatics and Telemechanics (translated from Russian by M. D. Friedman, 572 California St., Newtonville, Mass. 22 pp.)

Author develops equations of motion for large deflections of pneumatic drive with slide-valve control. Treatment assumes: Bernoulli equation for steady motion, isothermal process, coefficients characterizing head losses in variable valve choke hole section are unchanged, no local head losses, no air leaks, invariance of air pressure behind cylinder. System involves three degrees of freedom not including slide valve.

Four variations of the three nonlinear equations which describe process of pneumatic drive are presented, including supercritical and subcritical discharge through both slide-valve choke holes; also supercritical region in filling chamber and subcritical in emptying chamber, and vice versa.

Equations are linearized for small oscillations about the equilibrium position by expanding the nonlinear terms in power series and retaining only linear terms. Linearization results in left side of equations being independent of piston displacement and pressure. Author states that this can be reason for results not corresponding to physical reality and leading to loss of one degree in eliminating variables. It is thus concluded that linearization of original nonlinear equations must be used with care. Region where linearization may be safely applied is specified.
W. J. Worley, USA

1019. **Lochner, J. P. A., and Keet, W. de V., A simple method of measuring the dynamic Young's modulus of concrete,** *J. sci. Instrum.* **32,** 8, 296–299, Aug. 1955.

A nonelectronic method for determining fundamental frequency of lateral vibration of prisms is described. Specimen is supported over a tunable Helmholtz resonator and struck with a hammer. Proper tuning of the resonator is detected by using a stethoscope. Frequency is read off a micrometer which adjusts the cavity. Absolute accuracy of the method appears to be within $\pm 1\%$. Instrument requires no power supply and no maintenance, is simple to operate but is slower than electronic methods.
E. A. Ripperger, USA

1020. **Graves, A., Applications of vibratory energy. Apparatus for determining elastic moduli,** *Engineering* **180,** 4684, 637–639, Nov. 1955.

1021. **Hansen, R. S., The theory of vibrating jets in liquids of variable surface tensions,** *Iowa St. Coll. J. Sci.* **30,** 2, 301–311, Nov. 1955.

The theory of jet oscillations in a liquid of time-dependent surface tension has been analyzed. To the extent that the surface tension change can be represented as linear over a single wave length, the wave length is approximately that given by the non-time-dependent equations with surface tension constant at the mean value over the wave length. A high-frequency low-amplitude oscillation will be superimposed on the principal jet motion, which should, however, present negligible complications under usual experimental conditions.
From author's summary

Wave Motion in Solids, Impact

(See also Revs. 1098, 1285, 1314)

1022. **Jones, R. P. N., Transient flexural stresses in an infinite beam,** *Quart. J. Mech. appl. Math.* **8,** 3, 373–384, Sept. 1955.

Author solves Timoshenko equation of beam vibration for a transverse point-load by use of Fourier transforms. Results are given as asymptotic approximations, thus avoiding the evaluation of inversion integrals. Extension of method to other types of loading is indicated.
H. N. Abramson, USA

1023. **Stoneley, R., The propagation of surface elastic waves in a cubic crystal,** *Proc. roy. Soc. Lond.* (*A*) **232,** 1191, 447–458, Nov. 1955.

Author postulates plane waves in an aeolotropic medium possessing cubic symmetry. Three elastic constants c_{11}, c_{12}, and c_{44} are involved in three equations of motion instead of Lamé parameters. Substituting the expressions with a factor $\exp(-kq_i z)$ for plane waves, these equations yield the first condition for q_1, q_2, q_3. For any (q_i) root of this equation, the ratio of displacement amplitudes can be found. Second condition is derived from boundary conditions (at the free surface $z = 0$) in which three components of stress are assumed to vanish. The discussion of the equation of Rayleigh-type waves is given for three cases: isotropic medium, cubic symmetry, and wave front either parallel to x axis at $z = 0$ or making a 45° angle with it. Numerical investigations for aluminum, copper, nickel, sodium chloride, potassium chloride, and calcium chloride show under what conditions waves of Rayleigh type can exist. If the surface rocks are anisotropic, the Rayleigh-type waves may have a transverse component. Transverse motion of Love wave type cannot exist except in the two cases of symmetry.
W. S. Jardetzky, USA

Elasticity Theory

(See also Revs. 1031, 1038, 1044, 1048, 1051, 1056, 1089)

1024. **Stokey, W. F., and Hughes, W. F., Tests of the conducting paper analogy for determining isopachic lines,** *Proc. Soc. exp. Stress Anal.* **12,** 2, 77–82, 1955.

The conducting-paper analogy is used to determine isopachic lines for a bar having a centrally located hole, under a load in tension; also for a square plate with compressive loads applied at opposite corners. Good agreement is obtained between several lines so obtained and lines plotted from values obtained by relaxation for the bar and by graphical integration for the plate. The work involved by solution by conducting paper analogy is stated as about equal to that involved in carrying out a solution by relaxation. A good account of the experimental setup and procedure is encompassed.
T. J. Higgins, USA

1025. **Conway, H. D., Stress distributions in orthotropic strips,** *J. appl. Mech.* **22,** 3, 353–354, Sept. 1955.

Author presents a numerical solution of stress distribution near two equal concentrated loads in oak strips with grain perpendicular and parallel to tensile forces. These forces act centrally and in the direction parallel to the longer sides. Author assumes: (1) that these forces are sufficiently apart to insure uniform stress distribution at the midsection between the loads; and (2) that one of the principal axes of orthotropy is in the direction of loading. Problem is solved by superposition involving solution of the biharmonic type of equation with constant coefficients. These coefficients are given in terms of moduli which, in turn, are de-

fined by the stress-strain equations. Further, author employs two stress functions of the Fourier integral form. Numerical values were obtained for cross sections at certain distances from the loads. These distances were selected to be fractions and multiples of the half width of the strip. In loaded portion of the strip, stress variations from average values were considerably greater for loading parallel to grain as compared with loading perpendicular to grain. Stress distribution became nearly uniform in a distance equal to twice the strip width. Author mentions that, prior to his numerical solution, certain discussions on this subject were introduced by A. E. Green. V. A. Valey, USA

1026. Smith, T. F. W., Uses of the Mohr circle pole, *Engineer, Lond.* **200,** 5207, 696–697, Nov. 1955.

The advantages are shown of using the pole of the Mohr circle in the graphical analysis of stress, strain, and second moments of area. Constructions based on the pole are given, which provide quick and direct solutions to common problems.

From author's summary

1027. Goodier, J. N., and Wilhoit, J. C., Jr., Axial displacement dislocations for the hollow cone and the hollow sphere, *Quart. appl. Math.* **13,** 3, 263–269, Oct. 1955.

Simple solutions in closed form are given for the dislocational states of stress in a hollow cone or a hollow sphere induced by making an axial cut, and imposing a rigid-body displacement of one face of the cut relative to the other, in the axial direction. The problems are solved by adaptations of the Saint Venant torsion theory and of J. H. Michell's theory of torsion of nonuniform shafts. From authors' summary by Y.-H. Pao, USA

1028. Born, J. S., and Horvay, G., Thermal stresses in rectangular strips—II, *J. appl. Mech.* **22,** 3, 401–406, Sept. 1955.

Authors give a very useful analysis of the stresses and displacements occurring in rectangular strips subjected to various longitudinal temperature discontinuities. To follow completely the theoretical analysis, it is necessary to refer to previous papers by G. Horvay, but this is well worth the effort.

Analysis refers to thin strips (plane stress), but authors show how results may be modified to include thick strips (plane strain). Results will be of particular use in judging the behavior of nuclear reactor fuel elements, in which such temperature discontinuities arise. J. M. Alexander, England

Experimental Stress Analysis

(See also Rev. 1100)

1029. Gross, N., and Lane, P. H. R., Stress-probing—a rapid method for stress-surveying, *Proc. Soc. exp. Stress Anal.* **12, 2,** 1–8, 1955.

A rapid method for measuring strains at different points on the surface of a structural member or pressure vessel. Slow cycles of loading are imposed upon the test member. The resulting range of deflection at each point in question is measured by a manually positioned mechanical extensometer. Examples of three strain surveys are described. Results show good agreement with electric resistance strain-gage measurements.

T. A. Hewson, USA

1030. Ligtenberg, F. K., The Moiré method—a new experimental method for the determination of moments in small slab models, *Proc. Soc. exp. Stress Anal.* **12, 2,** 83–98, 1955.

Author presents modification of method of G. Bowen [*Engng. News Record* **143,** p. 70, 1949] to simplify technique. Simplification consists of making double exposure of reflected grid pattern for loaded and unloaded (or partially loaded) model. Screen has chevron grid. Model of silvered plastic or polished brass distorts reflection of screen pattern, depending upon change in curvature of model. Single differentiation of slope yields moment. Accuracy of 5% except at built-in edges is possible. Much less equipment and effort than previous methods are required to obtain solution. Reviewer concurs.

F. J. Mehringer, USA

1031. Racké, H. H., Transparent model determination of three-dimensional stresses by means of small spherical inclusions (in German), *Forsch. Geb. Ing.-Wes.* **21,** 5, 133–144, 1955.

A spherical hole in an unloaded body, upon mechanical loading, transforms into an ellipsoid whose axes coincide with the directions of principal stress. The length of the axes, as compared with the radius of the original sphere, is a measure for the values of the principal stresses. So, heating a model with spherical gas-filled holes under mechanical load, in the same manner as with "frozen-stress" techniques, and cooling it down, the shape of the ellipsoid is frozen-in and its dimensions can be determined by means of a measuring microscope. A liquid-filled spherical hole behaves in the same way, only the hydrostatic pressure in the liquid remains undetermined and, therefore, only the differences of the principal stresses can be determined. Author suggests the employment of embedded plastic balls (polystyrene) in a model material of thermosetting Araldite B. The balls should be perfectly spherical and contain a well-known percentage of gas, so that the hydrostatic pressure can be kept sufficiently low. In this way, the heated model (150 C) behaves elastically and the polystyrene as a pure compressible liquid.

It was found experimentally that the mutual influence of two balls could be neglected if their distance apart was more than four times the diameter. For balls in the neighborhood of, or at a boundary, the required data for the evaluation of the stresses are also determined experimentally.

An alternative method is to use balls of a material with a melting point well above the relaxation temperature of the model material. After heating the loaded model at a temperature above the melting point of the ball material (Plexiglas), cooling it down to a temperature below this point and above the relaxation temperature of the model material (112–115 C), the internal stresses in the model material are relieved and, on final cooling down to room temperature, the model material shows a frozen-stress pattern around the deformed balls, which can be treated in the normal way on a photoelastic bench and from which the stresses can be determined. As the balls have a diameter of 0.5–1 mm, the stress gradient in the model should be low, which means that the method may be less suitable for areas with high stress gradients or stress concentrations and with small models.

R. G. Boiten, Holland

1032. Rocha, M., General view of the present status of the experimental method of structural design (in Portuguese), *Minist. Obras Públ., Lab. Engen. civ. Lisboa,* Pub. no. 52, 20 pp., 1954.

Conditions of similarity are established for shapes, materials, and forces. Reference is made to different kinds of extensiometers and brittle-coating method. Photoelasticity is very briefly considered. Paper has no novelty, but reviewer believes it can be useful for engineers because it is a brief and unusually clear survey of the field. H. F. Long, Argentina

1033. Lardy, P., Model experiments on structures (in German), *Bauingenieur* **30,** 10, 360–363, Oct. 1955.

Rods, Beams, Cables, Machine Elements

(See also Revs. 990, 1009, 1014, 1015, 1017, 1019, 1022, 1057, 1070, 1078, 1098)

1034. Ericksen, W. S., Bending and torsion of circular cylinder cantilever beams of cylindrically aeolotropic material, ASME Ann. Meet., Chicago, Ill., Nov. 13–18, 1955. Pap. 55—A-41, 6 pp., 1955.

Paper deals with problem of cantilever, circular tube carrying transverse force and twisting moment at free end if tube is of aeolotropic material whose axis of symmetry coincides with axis of tube. Equations are given for stresses and displacements. No numerical results are given but equations have form which makes computation easy. G. W. Housner, USA

1035. Barbré, R., Nonuniform torsion of rolled and composite I-beams (in German), *Bauingenieur* **30,** 10 (Short Technical Note), 373–375, Oct. 1955.

Bending stress at section along length of I-beam under torsion is determined theoretically, assuming rotation of section combined with bending of beam web. Theoretical results are compared with experimental. Convenient procedure to theoretically and graphically determine stress in various composite I-beams, with uniform and also stepwise changing sections, is presented.
D. Kececioglu, USA

1036. Symonds, P. S., Large plastic deformations of beams under blast type loading, *Proc. second U. S. nat. Congr. appl. Mech.*, June 1954; Amer. Soc. mech. Engrs., 1955, 505–515.

Typical blast loading curves are used to determine plastic deformations of simply supported and built-in beams having uniformly distributed or central concentrated loads. The elastic strains are assumed negligible and the "rigid-plastic" analysis is used, which limits the usefulness of the method.
Y. V. G. Acharya, India

1037. Onat, E. T., and Shield, R. T., The influence of shearing forces on the plastic bending of wide beams, *Proc. second U. S. nat. Congr. appl. Mech.*, June 1954; Amer. Soc. mech. Engrs., 1955, 535–537.

Slip-line field theory has been used to determine upper bounds for critical bending movement and shearing force combinations for a wide beam of rectangular section. [See AMR **8,** Rev. 3392.]
Y. V. G. Acharya, India

1038. Sheng, P.-L., Note on the torsional rigidity of cylinders of circular sector cross sections, *ZAMP* **6,** 5, 416–419 (Brief Reports Section), 1955.

Author's previous results for the torsional rigidity of a semicircular shaft [AMR **5,** Rev. 635] are extended to cylinders of circular sector cross section. Closed form results involving *L*-functions are found by obtaining the exact sum of several series. Explicit expressions for the torsional rigidity for 16 particular sector angles are given. H. G. Maier, USA

1039. Zickel, J., Bending of pretwisted beams, *J. appl. Mech.* **22,** 3, 348–352, Sept. 1955.

Using equations obtained in a previous work, author finds the influence of pretwist on the flexibility of a straight beam with doubly symmetric cross section. He chooses a cruciform section and a thin strip as examples. His results show that pretwisting tends to equalize the resistance to bending in all directions, and that pretwisting causes an increase in flexibility when compared with elementary theory. R. E. Beckett, USA

1040. Gillies, A. W., Bending of a straight beam under transverse loading, impulse and step functions in elementary problems, *Engineering* **180,** 4672, 211–213, Aug. 1955.

In a previous article [*Phil. Mag.* (7) **37,** p. 813, Dec. 1946], author developed the general solution for the bending of an initially straight beam under arbitrary loading by a systematic extension of Macaulay's method. The sign conventions and symbols are summarized in the equations

$$W = -(dS)/(dx) = (d^2M)/(dx^2) = EI(d^3\theta)/(dx^3) = EI(d^4y)/(dx^4)$$

The present method makes use of the function $\{x - a\}^n$, the significance of the curly bracket being that the function is zero if the number $x - a$ inside the bracket is negative, but is the ordinary power $(x - a)^n$ if $x - a$ is positive. With $n = 0$, the function $\{x - a\}^n = 0$ if $x < a$, and $\{x - a\}^n = 1$ if $x > a$; i.e., this is a "unit step function," jumping from 0 to 1 at $x = a$. The general power $\{x - a\}^n$ may be regarded as the product of $(x - a)^n$ and the unit step function.

The unit step function may be regarded as a limiting form of a continuously differentiable function. This leads to the development of a concentrated load function and a concentrated moment function. A conventional system of Cartesian coordinates and successive integration from the equation expressing the loading across the beam are used. Use of the step functions described overcomes difficulties in continuity associated with partial distributed loads, concentrated loads, and concentrated moments.
From author's summary by A. G. Sharp, USA

1041. Csonka, P., The stability of the freely supported and laterally restrained beam (in Hungarian), *Magyar Tud. Akad. Oszt. Közl.* **15,** 1/2/3/4, 139–150, 1955.

This is an investigation of the stability under uniformly distributed load of a beam of rectangular cross section, freely supported at the two ends in the vertical plane and laterally restrained in the horizontal plane at the ends and at the center of the span.

The two points of vertical support are assumed to be at the same vertical distance above the axis of the beam. The points of horizontal support are on a straight line parallel to and above the axis.

It was established that a beam with a width-to-depth ratio not exceeding 1 to 10 cannot become unstable due to an increase in load. The stability of the beam is independent from the vertical distance above the axis of the vertical and horizontal supporting points.
From the author's summary by D.Vasarhelyi, USA

1042. Sciammarella, C. A., Shear strength of reinforced-concrete beams (in Spanish), *Construcciones* no. 113, 159–169, Oct. 1954.

As the result of his 56 tests on reinforced-concrete beams failing in shear, Sciammarella expresses the ultimate strength of them by a formula of only two terms: one constant, the ultimate strength of the beam without stirrups; and the other of lineal variation according to percentage of stirrups. This formula would also be valid for beams tested by other investigators such as Arthur Clark [AMR **5,** Rev. 1374] and Mörsch Emil ["Der Eisenbetonbau," I Band, 2 Halfte, Stuttgart 1929].

Subsidiarily, Sciammarella expresses the "nominal" shearing stress as the sum of concrete tensile strength and yield point stress of web reinforcement (proportionally to its amount). Through recent works of K. G. Moody, I. M. Viest, and R. C. Elstner guided by Prof. E. Hognestad [*J. Amer. Concr. Inst.* **26,** nos. 4, 5, 6, 7, 1955], the constant term of Sciammarella's proposed

formula would be the contribution of the beam without web reinforcement when "the initial diagonal tension crack" is developed. This would be the explanation of posterior increase of beam strength in direct proportion of percentage of web reinforcement. But speaking of nominal shearing stress, it is not easy to explain why an ultimate limit formula contains concrete tensile strength, because, by yielding of stirrups, the diagonal cracks are wide open. For that, reviewer believes that author could complete his interesting work and clear up these points.

J. L. Delpini, Argentina

1043. Huey, S. E., Simple moments and moment design, *J. Amer. Concr. Inst.* **27,** 2, 361–374, Nov. 1955.

Starting with the moment for a simply supported single span, a simple and direct method of moment design for prismatic beams and frames is outlined. The method is exact but lends itself to quick and close approximations for preliminary design.

From author's summary

1044. Weiss, G., and Payne, L. E., Torsion of a shaft with a toroidal cavity, *J. appl. Phys.* **25,** 10, 1321–1328, Oct. 1954.

Paper gives the solution to the torsion problem for a near-cylindrical shaft of circular section having a toroidal cavity. Since the interpretation of the axially symmetric problem as a flow problem in five dimensions is well known, the first part of the paper is devoted to developing a method for handling the flow problem about an n-dimensional ring-shaped body of general cross section. In the second part of the paper, this method is applied to the case of an n-dimensional torus ring. The case $n = 3$ then yields the solution to the classical flow problem, and $n = 5$ gives the solution to the torsion problem under consideration.

From authors' summary by F. S. Shaw, Australia

Plates, Disks, Shells, Membranes

(See also Revs. 1011, 1012, 1013, 1028, 1029, 1067, 1068, 1069, 1088, 1089, 1095, 1099, 1287, 1289)

1045. Fuchssteiner, W., Plates with support on two or three edges (in German), *Beton u. Stahlbeton* **50,** 9, 240–244, Sept. 1955.

Paper deals with rectangular plates simply supported at the relatively long edge and the two short edges, in such cases emphasizing the importance of twisting moments, insufficiently pointed out in literature. An approximate method is given starting from a linear deflection state in sections perpendicular to the long edge. It obviously gives good values in the case $l/b \to \infty$; remaining small load delivers only small corrections. Criticizing recent papers by Goriupp ["Die dreiseitig gelagerte Rechteckplatte, I," *Ing.-Arch.* **16,** 2, 77–98, 1948], only omission of twisting moments in plottings is pointed out, but formulas and numerical values are appreciated. Plate simply supported at two neighboring edges is discussed briefly. [See correction to paper, title source **50,** 12, p. 322, Dec. 1955].

W. Mudrak, Austria

1046. Godfrey, D. E. R., Normal loading on a wedged-shaped plate, *Aero. Quart.* **6,** part 3, 196–204, Aug. 1955.

Author shows that problems involving normal loading of thin plates with wedge-shaped boundaries can be treated very successfully by means of the Mellin transform. This success is due to the fact that the transformed biharmonic equation in polar coordinates is easily capable of solution. Complex combinations of the stress resultants and stress couples are formed and expressed in terms of the transform of the deformation. It turns out that these combinations facilitate calculation of the stress resultants and stress couples in a particular problem. The method is illustrated by solving the problems of a clamped, semi-infinite plate with uniform loading and with a concentrated load on the axis of symmetry. The success of the Mellin transform in treatment of the present problem suggests that the method may facilitate solution of a larger class of problems as well.

J. H. Baltrukonis, USA

1047. Vreedenburgh, C. G. J., and van Wijngaarden, H., New progress in our knowledge about the moment distribution in flat slabs by means of the Moiré method, *Proc. Soc. exp. Stress Anal.* **12,** 2, 99–114, 1955.

Application of method described in Rev. 1030 in this issue. Authors find results check values of moments for interior panels obtained by Vreedenburgh and Stokman [Eighth Congr. theor. appl. Mech., Istanbul, 1952]. Results check well with experimental data but not with A.C.I. Code Requirements (A.C.I. 318–47).

From authors' summary by F. J. Mehringer, USA

1048. Contri, L., Rectangular plate with linearly variable thickness (in Italian), *G. Gen. civ.* **93,** 2, 136–142, Feb. 1955.

Problem treated in the paper is search of the general expressions of transverse displacement and curvatures of a thin plate in the particular case of a rectangular plate whose thickness is constant along the x-axis and linearly variable along the y-axis, and which is simply supported along the two edges parallel to the y-axis.

The rigorous solution is given for the value of 1/3 of Poisson's ratio, using the Levy-Estanave simple-series solution; general solution involves exponential integrals; additional particular solution is expressed by a double Fourier series involving sine integrals and cosine integrals.

A method of correction of preceding solution is given for the case where $\nu \neq 1/3$.

Two numerical examples are given in detail; the second is a practical case of plane tank wall subjected to a trapezoidal pressure diagram.

Ch. Massonnet, Belgium

1049. Woinowsky-Krieger, S., A method for the determination of the bending moment of plates under concentrated loads (in German), *Ing. Arch.* **23,** 5, 349–353, 1955.

Usual difference method for calculation of plates under action of loads distributed uniformly on small rectangular or circular areas is troublesome, lengthy, and requires simple relations between lengths of load areas and of the plate. Restricting the consideration to the bending moments in the center of mentioned area and using an earlier paper [AMR **7,** Rev. 2796], developed method separates influences of size and form of this area on the one hand, and the plate size, form, and boundary conditions on the other, and allows going from a special case to others differing only by areas, form, and size. After estimating the accuracy to be reached by difference method, two examples are given: the square plate supported only at its corners with central load, and the likewise loaded square plate with uniformly distributed soil pressure. Method provides effectiveness for use of present calculations for related cases.

W. Mudrak, Austria

1050. Williams, M. L., and Owens, R. H., Stress singularities in angular corners of plates having linear flexural rigidities for various boundary conditions, *Proc. second U. S. nat. Congr. appl. Mech.*, June 1954; Amer. Soc. mech. Engrs., 1955, 407–411.

In a continuation of AMR **6,** Rev. 2486, authors have extended the study of stress singularities at the vertex of circular sectorial plates to consider the effect of variable thickness. The solution

is effected by assuming that the deflection and plate rigidity are given by the products of a power function of r and trigonometric functions of θ, where r and θ are polar coordinates. There is no applied loading except at the circular boundary of the sector.

The eigenequations for the six possible double combinations of simple, fixed, and free boundary conditions at the radial edges (the circular boundary is free in all cases) are given when the flexural rigidity is a power function of r but independent of θ. When the flexural rigidity varies both radially and tangentially, a solution is given for the case in which both radial edges are simply supported.

Authors show that the critical value of the central angle above which stress singularities may occur at the vertex is dependent upon the exponent of the power function of r when the rigidity varies only radially. Specifically, this means that no stress singularities will occur at the vertex if a radial section of the plate is cusplike at the vertex. The curved upper surface (symmetric about the middle plane with the lower surface) is concave, i.e., will hold water.

When tangential variation of flexural rigidity is taken into account, authors noted that the first eigenvalues were near to those determined with no tangential variation for the one case considered, and hence infer that this is likely to be true for other cases provided that the tangential variation is reasonable.

Two typographical errors are noted in this paper. The last inequality $m > 3$ in the abstract should be $m < 3$. A parenthesis has been left out of Eq. (1). K. Arnstein, USA

1051. **Giencke, E., Fundamental equations for orthotropic plate with eccentric stiffeners** (in German), *Stahlbau* **24,** 6, 128–129, June 1955.

In this paper, author extends the well-known method of Huber for treating a stiffened plate as an equivalent homogeneous orthotropic plate to include stretching and shearing of the so-called middle surface. Bending and twisting stiffness factors for plates with stiffeners only on one side are determined using elementary beam theory in connection with the stiffeners. Strains associated with stretch and shear in the plane of the middle surface are introduced in terms of the usual stress function. Finally, a fourth-order differential equation with derived constant coefficients is developed. Author states that he expects to present a detailed paper with numerical problems. He also says that R. Heilig has used his equations in connection with numerical problems treated in an unpublished work.

W. H. Hoppmann, II, USA

1052. **Rudiger, D., State of stress and deformation of axially symmetrical membranes with arbitrary meridian curve** (in German), *Ing.-Arch.* **22,** 5, 336–347, 1954.

The x-axis is the axis of rotation. The equation of the meridian curve is $\rho = \rho(x)$. Author starts to derive the partial differential equations which govern the state of stress. Although unlike plane membranes, these differential equations follow from equilibrium considerations alone, which means that the state of stress is statically determinate. By separation of variables, the partial differential equations are reduced to ordinary differential equations in x, where the stress flows and loads vary in circumferential direction according as $\cos n\psi$ or $\sin n\psi$. Also, the equations for the corresponding displacements are given. Of the differential equations, the general integrals are given for arbitrary functions $\rho(x)$, with $n = 0$ and $n = 1$ and for $n > 1$ with functions ρ satisfying $\rho'' = \pm c\rho$ and $\rho'' = \pm c\rho^{-3}$. If the radius of curvature of the meridian curve is directed outward, discontinuities in the boundary conditions are transmitted along the whole membrane. These discontinuities, also formerly observed, are further analyzed. J. P. Benthem, Holland

1053. **Nowinski, J., The deflection of a circular membrane supported on an elastic ring** (in Polish with English summary), *Arch. Mech. stos.* **5,** 295–307, 1953.

A membrane described in the title is subjected to a constant normal distributed load. Bottoms of certain cylindrical containers can be regarded as such membranes. Deflections and stress function for membranes are controlled by a system of two partial differential equations known as equations of von Karman. For a circular membrane this system was solved by H. Hencky [*Z. Math. Phys.* **63,** 311–317, 1914] in rapidly convergent series whose coefficients have to be determined from boundary conditions. Author finds the coefficients of the first four terms from the condition that on the boundary the circumferential strain of the plate must equal that of the ring. He discusses his solution with the aid of graphs. The loss of stability is excluded.

T. Leser, USA

1054. **Naghdi, P. M., and DeSilva, C. N., Deformation of elastic ellipsoidal shells of revolution,** *Proc. second U. S. nat. Congr. appl. Mech.,* June 1954; Amer. Soc. mech. Engrs., 1955, 333–343.

Deformation of thin elastic ellipsoidal shells of revolution of uniform thickness under axisymmetric loading are considered in detail. By means of a more recent method of asymptotic integration due to Langer, a solution is obtained which is valid at the apex of the shell and involves Kelvin functions. This solution reduces in the limit to the known theory of shallow spherical shells. Specifically, the stress distribution is obtained for ellipsoidal shells under both distributed and edge loadings.

From authors' summary by S. U. Benscoter, USA

1055. **Nash, W. A., General instability of ring-reinforced cylindrical shells subject to hydrostatic pressure,** *Proc. second U. S. nat. Congr. appl. Mech.,* June 1954; Amer. Soc. mech. Engrs., 1955, 359–368.

A solution is presented for the problem of the general instability failure of ring-stiffened cylindrical shells subject to a hydrostatic pressure p acting both radially and axially. In this type of failure both the shell and the reinforcing rings collapse simultaneously under formation of a number of lobes, spaced uniformly around the circumference of the cylinder and extending between the bulkheads (which are supposed to be infinitely stiff) from one end of the shell to the other. A plausible displacement configuration (evidently suggested by experimental evidence) is introduced containing only four unknown constants. The method used to attack the problem is that of minimization of the total potential energy.

Author concludes his paper with the remark that its purpose was to indicate a solution based upon the classical small deformation theory for an initially perfect shell. The fact that for a given numerical example the calculated critical pressure p amounts to 1222 psi, whereas the experimental value proved to be 675 psi, requires, as author rightly states, further investigation.

C. B. Biezeno, Holland

1056. **Vinokurov, S. G., Thermal stresses in plates and shells** (in Russian), *Izv. Kazan. Filial. Akad. Nauk SSSR. Ser. Fiz.-Mat. Tekn. Nauk.* **3,** 18–38, 1953.

The preliminary part of this paper gives a general formulation in tensor notation of the equations governing thermal stresses in thin elastic plates and shells. In the remaining part of the paper the solution is given of certain problems associated with a circular plate for which no edge displacement, in either the radial or transverse directions, is permitted. First, an exact analysis is given of the effect on free transverse vibrations due to a uniform change in temperature. Second, Galerkin's method is applied

to discuss the behavior under uniform transverse load when a constant temperature difference is maintained across the plate thickness. In each of these cases the plate is supposed built-in at its edge. Third, an energy method is applied to discuss the behavior under uniform transverse load with a uniform change in temperature. In this case the plate is supposed simply supported at its edge.

Courtesy of Mathematical Reviews H. G. Hopkins, England

1057. Bijlaard, P. P., Stresses from radial loads and external moments in cylindrical pressure vessels. Design information on deflections, bending moments and membrane forces, and on the influence of internal pressure, *Weld. Res. Suppl.*, pp. 608s–617s, Dec. 1955.

See AMR **8**, Rev. 1326.

1058. Holms, A. G., and Repko, A. J., Correlation of fir-tree-type turbine-blade fastening strength with mechanical properties of materials, ASME Ann. Meet., Chicago, Ill., Nov. 13–18, 1955. Pap. 55—A-122, 7 pp., 1955.

Some materials under consideration for aircraft gas-turbine disks are notch sensitive at certain operating times, temperatures, and stress levels. Prediction of engine life requires knowledge of the type of mechanical-property test that will correlate with engine life and requires knowledge of the quantitative relationship. Elevated-temperature time-dependent spin tests were run on model disks with fir-tree blade fastenings. Material and test conditions were selected to cover a wide range of notch sensitivity. Results showed that life for tensile mode failures could be predicted from notched rupture tests.

From authors' summary

Buckling Problems

(See also Revs. 1036, 1037, 1055, 1114)

1059. Bölcskei, E., Limit strength of elastic compressed bars (in Hungarian), *Mélyépítéstudományi Szemle* no. 8, 365–370, Aug. 1955.

Author investigates the load-carrying capacity of the eccentrically compressed bar in the general case when Hooke's law is not valid for the material of the otherwise elastic bar, but the stress-strain relation $\epsilon = \varphi(\sigma)$ is known and is single-valued. Further assumptions: The bar is straight and the force P of eccentricity e_0 is parallel to its axis. Under load-carrying capacity are understood pairs of values P, e_0 that can produce ultimate stresses σ_{1t} and σ_{2t} in the two extreme fibers. Only the simple case is investigated in which the cross section of the bar consists of two chord plates of equal size (Ryder's model). The differential equation of the flexured bar axis is established and the relation between slenderness ratio (λ) and the pairs of values P, e_0 causing critical state are determined. Two examples are presented, both for wooden bars. In the first case, the modulus of elasticity $E = 105\ t/\text{cm}^2$ is constant; that is, the problem is solved for the case $\epsilon = \varphi(\sigma) = \sigma/E$, demonstrating also that in case of $e_0 = 0$ the load-carrying capacity is equal to the Euler buckling load. In the second example, ϵ is assumed as a cubic polynom of σ. At $e_0 = 0$, the solution results for the assumed conditions in a somewhat lower load-carrying capacity than the first Engesser buckling load, and substantially lower than that of Euler.

The paper starts from eccentrical buckling and treats buckling as a strength problem, without mentioning the latter. The problem has long been solved for materials for which Hooke's law holds. The author solves it in general, valid for a bar material of any stress-strain law $\epsilon = \varphi(\sigma)$, but perfectly elastic.

L. Korányi, Hungary

1060. Schnell, W., Calculation of the critical buckling load of bars having multiple sections or supports with the aid of matrixes (in German), *ZAMM* **35**, 6/7, 269–284, June/July 1955.

Method is developed for calculating critical elastic buckling load of bars over several supports or having discontinuous stiffness. Solution of basic fourth-order beam-differential equation with boundary conditions of shear, moments, slope, and deflection is expressed in matrix form. Critical load is obtained from a two-rowed subdeterminant. Cases covered include those with elastic supports. Table of trigonometric eigenfunctions is included.

C. M. Tyler, Jr., USA

1061. Bijlaard, P. P., Buckling of columns with equal and unequal end eccentricities and equal and unequal rotational end restraints, *Proc. second U. S. nat. Congr. appl. Mech.*, June 1954; Amer. Soc. mech. Engrs., 1955, 555–562.

An analytical method is given for calculating the buckling stress of eccentrically loaded columns with any combination of end eccentricities and end restraints. In the general case, the deflections will gradually increase with increasing load until, due to plastic action, a maximum is reached, which is the eccentric buckling load. However, for columns with equal end restraints and equal and opposite end eccentricities, a bifurcation point is reached at which the column buckles in a superimposed symmetrical mode.

From author's summary by C. B. Biezeno, Holland

1062. Yoshihara, H., On the lateral buckling of a tapered cantilever beam, *AF tech. Rep.* WADC TR 54-477, 17 pp., Oct. 1954.

Formulas are given to compute the lateral buckling loads of a cantilever beam linearly tapered in both width and height of the beam cross section and loaded by a concentrated force of arbitrary orientation acting at the free end. A perturbation method is used in which the unperturbed state is given by the Euler buckling. The results from the second-order perturbation are sufficient to cover a wide range of loadings and beam configurations. From author's summary by S. E. Kindem, Norway

1063. Evans, R. H., and Lawson, K. T., Ultimate strength of axially loaded columns reinforced with square twisted steel and mild steel, *Struct. Engr.* **33**, 11, 335–343, Nov. 1955.

1064. Carlson, R. L., and Schwope, A. D., A method for estimating allowable load capacities of columns subject to creep, *Proc. second U. S. nat. Congr. appl. Mech.*, June 1954; Amer. Soc. mech. Engrs., 1955, 563–568.

Following P. G. McVetty [*Mech. Engng., N. Y.* **56**, p. 149, 1934] authors plot "iso-stress-strain" curves, viz., relationships between stress and total strain at constant time, derived from ordinary creep curves at constant stress. A creep buckling theory for columns is built up, introducing a fictitious column having the same load and the same geometric and elastic properties as real column but such creep properties as to yield stress distributions that are described by segments of iso-stress-strain curves. Fictitious column is proved to be weaker than real column and thus to yield shorter time to failure in a buckling test. Authors state that buckling load may be computed, using iso-stress-strain curve as a real stress-strain curve and applying available methods. Authors prefer such simple treatment as it gives a conservative approximation to buckling load for a given time to failure, the reason being that, in practice, numerous variables which are not easily specified will influence the result.

The theory as outlined above is worked out in detail for columns of 24S-T aluminum alloy of different slenderness ratio.

Initial deflection is assumed according to a sine curve. Experiments with columns at 350 and 450 F show satisfactory agreement for short time tests and increasingly conservative approximation for longer duration of tests. It is indicated that the tangent modulus, as taken from the iso-stress-strain curves, would give a simple conservative estimate. [For reviewer's comments, see following review of paper by H. W. Baer.]

F. K. G. Odqvist, Sweden

1065. Baer, H. W., Prediction of very short time creep buckling from very short time tensile creep properties, *Proc. second U. S. nat. Congr. appl. Mech.*, June 1954; Amer. Soc. mech. Engrs., 1955, 569–576.

Using the well-known interpolation formula of McVetty [*Mech. Engng., N. Y.* **56,** p. 149, 1934] for total creep in both tension and compression, author calculates isochronous stress-strain relations from which a "tangent modulus" may be computed. In adherence to the Shanley concept of inelastic buckling, this modulus is introduced into the Euler formula for columns with the view to obtain lower limits for the buckling load corresponding to prescribed temperature and lifetime of thin-walled cylinders in compression. There follows a short account of experiments with magnesium alloys in temperature range 70 to 600 F to confirm above theory, the temperature of specimen being claimed to be controlled to within no better than ±5 F. Buckling tests were carried out with uniform load rate and prove to give buckling loads well above calculated values, the theory thus giving a prediction on the conservative side. The loading device aims rightly at avoiding dynamic amplification of load.

Reviewer's comment to this paper and Carlson-Schwope paper in preceding review: In reviewer's opinion, the theories of both papers involve hypotheses difficult to control. A better approach permitting a deeper insight into phenomena of creep buckling has been initiated by N. J. Hoff and followed up by others [AMR **7,** Revs. 1785, 1786, 2444; **8,** 1002; and J. A. Hult, *J. appl. Mech.* **22,** p. 432, 1955]. F. K. G. Odqvist, Sweden

1066. Nagai, T., One note for measurement of buckling stress in plate structure, *Bull. Fac. Engng. Yokohama nat. Univ.* 4, 41–49, Mar. 1955.

Author presents a method for determining the elastic compressive buckling stress of plate elements from strain gage data. Justification of the procedure is offered by a theoretical analysis using strain energy. Small initial deflections are permitted. Author's analysis shows that the postbuckling compression load is a linear function of the initial buckling load and the square of the bending strain in the plate elements. Hence, by plotting measured load versus the square of the bending strains, author suggests that the buckling load may be determined by the intersection of a straight line through the postbuckled data and the load axis. Experiments performed on thin mild-steel angles appear to show good agreement with theoretical results for the elastic region. N. Grossman, USA

1067. Anderson, R. A., and Semonian, J. W., Charts relating the compressive buckling stress of longitudinally supported plates to the effective deflectional and rotational stiffness of the supports, *NACA Rep.* 1202, 19 pp., 1954.

See AMR **7,** Rev. 459.

1068. Federhofer, K., Stability of circular cylindrical shell with slightly variable wall thickness, *Anz. Akad. Wiss. Wien* **89,** 1, 7–12, Jan. 1952.

Only axial symmetrical buckling is considered. Author writes differential equation for subject problem in terms of variable V and its derivatives with respect to dimensionless axial coordinate. V is product of squared variable wall thickness and slope of generatrix with respect to shell axis. Small deflection theory is used. Considering case of constant wall thickness as unperturbed case, differential equation is solved by using method of perturbation theory for eigenvalue problems. Since variation of thickness is assumed to be slight, only first-order perturbation is considered. Results are given for critical axial stresses in cases of linear and quadratic variations of wall thickness.

P. P. Bijlaard, USA

1069. Yoshimura, Y., On the mechanism of buckling of a circular cylindrical shell under axial compression, *NACA TM* 1390, 46 pp., July 1955.

See also AMR **8,** Rev. 629.

1070. Langhaar, H. L., Boresi, A. P., and Carver, D. R., Energy theory of buckling of circular elastic rings and arches, *Proc. second U. S. nat. Congr. appl. Mech.*, June 1954; Amer. Soc. mech. Engrs., 1955, 437–443.

The hoop strain at any point in a circular ring or curved beam that is deformed in its plane is expressed in terms of the displacement vector of the centroidal axis. The most important quadratic terms in the displacement components are retained. The hoop-strain formula leads to a strain-energy expression that includes the most important cubic terms in the displacement components. As an illustrative application, this formula is applied to the problem of buckling of a semicircular arch loaded by a concentrated force at its center. Some related experimental data are presented.

From authors' summary by C. J. Bernhardt, Norway

Joints and Joining Methods

(See also Rev. 1078)

1071. Sandiford, F. G. C., Developments in mechanized welding in the aeroengine industry, *Instn. Mech. Engrs. Preprint,* 21 pp., 1955.

1072. Flint, A. R., An analysis of the behaviour of riveted joints in aluminum alloy ships' plating, *N. E. Cst. Instn. Engrs. Ship. Trans.* **72,** part 2, 84–122, Dec. 1955.

An experimental study and a theoretical analysis of lap and butt joints in AlMg plate (N-6) with AlMg and mild steel rivets are presented. Different methods of riveting, some types of rivets, geometry of joint, and their effect on stiffness, strength, and watertightness are studied. Theoretical analysis is based on elastic theory. Comparisons are made between experiment and theory. Conclusions are presented in extensive recommendations for designing riveted joints in N-6 plating.

J. Schyve, Holland

1073. Mordfin, L., Creep and creep-rupture characteristics of some riveted and spot-welded lap joints of aircraft materials, *NACA TN* 3412, 53 pp., June 1955.

Author has investigated the creep of riveted aluminum-alloy joints at 300, 400, and 500 F, finding out: (a) The creep of joints is considerably greater than that of the unriveted sheet, although not so large that the creep of the sheet is negligible compared with that of the joints; (b) a correlation between the creep of a joint and the creep of its component materials in tension, bearing, and shear may be possible; (c) a rough estimate of the creep-rupture strength of a joint may be obtained by assuming the creep-rupture efficiency at the temperature in question to be equal

to the room-temperature efficiency of the joint; (d) an empirical relation is proposed to give more accurate estimates of the load required to produce creep rupture of a joint at a specific temperature in a given time.

Spot-welded lap joints of cold-worked austenitic stainless steel were tested at 800 F, showing that the creep is negligible, at least up to 200 hr.

Equipment and test techniques used in testing are described.

H. O. Albano, Argentina

1074. Brock, G. R., The strength of nailed timber joints, *Timber Technol.* **64,** 2199, 19–21, Jan. 1956.

Tests are described concerning the influence of (1) predrilling with $^5/_{64}$, $^1/_8$, or $^5/_{32}$-in. drills, and (2) clinching parallel or perpendicular to load direction on the effectiveness of two- and three-member compression joints of European redwood (0.37 sp.gr.; 16% m. c.) immediately after assembly with two 16d (8-gage) low-carbon-steel plain-shank round-wire nails, loaded laterally (shear load) and parallel to the grain and axes of the lumber pieces, at constant rate of motion of crosshead of 0.1 in./min. Loads at joint slips of 0.006 and 0.030 in. and maximum loads are presented.

Predrilling for nonclinched nails of 3-in. length and of clinched nails of $3^1/_2$-in. length increased the average ultimate load-carrying capacity of the joints from 6 to 17% and from 3 to 17%, respectively.

Clinching $^1/_2$ in. of $3^1/_2$-in. nails parallel to grain in opposite direction to load decreased the effectiveness of two-member joints at ultimate load from 5 to 11%, and increased the effectiveness of three-member joints at ultimate load from 9 to 17%. As compared with clinching parallel to grain in opposite direction to load of two-member joints, clinching parallel to grain in same direction as load, however, increased the ultimate load from 34 to 40%. Furthermore, clinching perpendicular instead of parallel to grain in opposite to or in same direction as load increased ultimate load for the not predrilled joints 59 or 15%.

In comparison with the two-member joints, the three-member joints proved to be 99% (not predrilled), 94% (predrilled $^5/_{64}$ in.), 115% (predrilled $^1/_8$ in.), and 106% (predrilled $^5/_{32}$ in.) more effective if assembled with nonclinched nails; 147, 135, 181, and 153%, respectively, more effective if assembled with nails clinched parallel to grain in opposite direction to load; and 103% more effective if not predrilled and with nails clinched perpendicular to grain.

In light of the present dispute in the United States as to the effectiveness of two-member versus three-member joints, this information is of particular interest. E. G. Stern, USA

1075. Dove, A. B., The influence of nail design and manufacturing practices on joint strength, *Wire and Wire Products* **30,** 6; 657–666, 724–725, June 1955.

Detailed descriptions are presented of improvements in steel nails by means of nail-shank deformations and changes in carbon content of steel, in nail-shank surface resulting from heat-treatment, and in design of nail points.

The comparative data presented for deformed nails were obtained with parallel-crested helix nails made of deformed wire. A comparison of the effectiveness of these nails with roll-threaded nails was avoided, despite the fact that roll-threaded nails (1) make up the large mass of threaded nails manufactured and (2) offer a far wider range of use—for instance, can be made of almost any metal and shape.

As to the specific data presented, the effect of speed of testing on the test data was given no consideration, although it is known that fast testing considerably distorted the effectiveness of nails, as presented elsewhere.

While the interpretation of some of the test data and some of the conclusions drawn may be challenged on basis of published and unpublished information and field considerations, the paper provides valuable data for the nail manufacturer and nail user.

E. G. Stern, USA

1076. Benthem, J. P., and De Vries, G., Investigation on the strength of Redux-bonded 75S-T lugs at rapidly applied loads, *Nat. LuchtLab. Amsterdam Rap.* no. S.466, 5 pp. + 5 figs., 1955.

Tests were carried out to determine the failing strengths of joints mentioned in the title. The load was applied to the specimen within a short time, which ranged from 0.01 sec up to 3 sec, while load-versus-time diagrams were recorded. No significant drop or increase in strength, compared with the results of static tests, is apparent.

Unlike during fatigue tests, stress concentrations do not seem to have special influence on the type of failure.

From authors' summary

1077. Schwartz, R. T., and Wittman, R. E., Adhesive bonded metal joints, *Prod. Engng.* **26,** 7, 170–173, July 1955.

Structures

(See also Revs. 1019, 1033, 1036, 1037, 1042, 1043, 1047, 1060) 1062, 1066, 1070, 1073, 1077, 1094, 1107, 1108, 1109, 1124, 1127,

1078. Bobek, K., Heiss, A., and Schmidt, F., Welded steel construction of machines [Stahlleichtbau von Maschinen], Berlin/Göttingen/Heidelberg, Springer-Verlag, 1955, vii + 183 pp. DM 24.

This book is written for designers and not for research men. It deals with four main chapters of welded construction: (1) The basic principles of light construction, particularly welded structures; (2) welded structures in electrical machines; (3) welded structures in machine tools; and (4) welded structures in engines. The coverage is thorough. Sketches and photographs are very clear. Economic considerations apply to the particular German situation and not necessarily to the U. S.

A. J. Durelli, USA

1079. Klein, B., Certain aspects of the problem of efficient structural design, *J. Franklin Inst.* **260,** 2, 107–114, Aug. 1955.

Author illustrates by a simple example the use of calculus of variations for deriving an optimum design. Reviewer sees no point in this exercise, since it is universally appreciated that the derivation of a constrained optimum is always theoretically possible, and, for very simple problems, the variational approach is undoubtedly the most elegant.

Real life engineering problems cannot be solved in this way and even the author's purple beam example lands him in nonlinear equations. It is the severe limitations of the classical variational approach that is the "raison d'etre" for such methods as the Rayleigh-Ritz, where the quantities that are at choice are represented by a series with unknown constant coefficients.

D. Williams, England

1080. Kozák, St., Simplification of the Cross method for symmetrical frames (in Hungarian), *Mélyépítéstudományi Szemle* **5,** 7, 322–325, July 1955.

Paper presents the modifications of the Cross method applied to increase the convergence of calculation, made first by reviewer ["Analysis of frames with movable joints," *Müeg. Közl.* **1,** 2, 22–

36, 1948; AMR **2**, Rev. 1381] and afterward by Naylor, N. ["Sidesway in symmetrical building frames," *Struct. Engr.* **28**, 4, 99–102, Apr. 1950]. The paper differs but little from the latter publication and brings out nothing new on the merits of the problem. P. Csonka, Hungary

1081. **Henderson, J. C. de C., and Bickley, W. G., Statical indeterminacy of a structure, a study of necessary topological condition relating to the degree of statical indeterminacy of a skeletal structure,** *Aircr. Engng.* **27**, 322, 400–402, Dec. 1955.

1082. **Rühle, H., A study of the effect of creep and shrinkage on dead load stresses in a statically indeterminate composite system made of precast and cast-in-place reinforced-concrete elements** (in German), *Beton u. Stahlbeton* **50**, 7, 194–200, July 1955.

This work is based on the following studies: (1) Dischinger's study on the effect of creep and shrinkage in statically indeterminate, monolithic reinforced-concrete structures [*Bauingenieur*, **35–36**, p. 539, 1937]; (2) and (3) studies made by Kloeppel [*Stahlbau* **2**, p. 17, 1951] and Sattler ["Theorieder Verbundkonstruktionen," Wilh. Ernst and Sohn, 1953] in connection with the effect of creep in concrete in statically indeterminate composite steel and concrete construction.

Using the above-mentioned sources, author shows that the plastic deformations of precast and cast-in-place reinforced-concrete elements, in a statically indeterminate structure, produce changes in internal stresses as well as in the indeterminate quantities. Furthermore, he applies the approximate method of Kloeppel and Sattler to composite concrete construction.

The mathematical derivations lead to differential equations in terms of the change in the indeterminate moment due to creep and shrinkage of concrete. In addition to mathematical derivations, author has presented computation procedures and solved numerical examples.

The computation procedures given are for determination of the effects of (1) creep, (2) shrinkage, and (3) the settlement of supports on indeterminate moments. The numerical examples included are (1) a three-span continuous bridge with haunched precast concrete stringers and cast-in-place slab and (2) an arch with precast ribs and cast-in-place concrete in between the ribs.

One of the conclusions that the author draws is that, in a continuous haunched beam, the change in dead load stresses due to creep is negligible. In conclusion, author compares the effect of creep, shrinkage, and settlement of supports in composite reinforced-concrete construction with monolithic construction.

Reviewer believes that this is a useful study. It shows clearly the difference between monolithic and composite construction.

N. Khachaturian, USA

1083. **Murakami, T., Generalized theorems of four moments and of three moments,** *Mem. Fac. Engng. Kyushu Univ.* **14**, 2, 101–124, 1954.

The theorem of four moments for a general plane structural framework is derived from slope-deflection equations obtained in a previous paper [title source **14**, 1, 1953]. Author's opinion is that problems can be solved more easily by direct application of the latter. R. M. Haythornthwaite, USA

1084. **Rusch, H., Considerations on the problems of safety in prestressed concrete structures** (in Spanish), *Inst. tecn. Constr. cem. Madrid* no. 145, 20 pp., 1954.

Paper presents a review of current design philosophy and proposes a system of load factors. Author first discusses the concept of factor of safety, pointing out the influence of the main variables, uncertainties of loads, reliability of the strength of materials, accuracy of prevailing methods of analysis, poor workmanship, etc. He then analyzes the different meanings of the term failure for the different types of structures, and stresses the need of defining what type of condition is understood by this expression—collapse load, large-deflection load, excessive cracking, etc. After these comments on the fundamental philosophy of design, author proposes a load-factor system: Load factor C_e taking into account the uncertainties loads; load factor C_a for the brittle type of failure in accordance with the suddenness of failure; load factor C_r covering the variation of the materials strength. Author applies this load-factor system to the case of prestressed-concrete members, considering separately the strength of the different zones—compressive zone, tensile zone, steel zone—under the different stages of loads.

Reviewer makes the following comments: Author's method is rather complicated and lacks experimental and theoretical basis. When studying the ultimate strength of a concrete member we must consider this member as a whole, rather than treat the concrete and steel elements as components that can be designed separately. All the theories on ultimate load design now available are derived from tests that give us the result of the composite action of both the materials. Regarding the behavior of the prestressed beams with bonded wires, there are two fundamental types of failure: (a) rupture or excessive elongation of the steel, and (b) crushing of the concrete without substantial elongation of the steel. Reinforced beams, which are the more important type to consider, have the first type of failure. This type of failure is not influenced by the prestresses [see Hajnal Konyi, *Mag. Concr. Res.*, no. 9, Mar. 1952]. The strength of concrete has little influence in this type of failure. Reviewer has performed a test with two identical prestressed beams, one at the age of seven days and the other at the age of four weeks, and has obtained practically the same ultimate bending moments. Failure of an over-reinforced beam with bonded wires depends on the strength, plasticity of concrete, shape of the section, and is largely influenced by the prestresses and bond between wires and concrete. In a beam with nonbonded, posttensioned wires, the failure is always a result of the crushing of the concrete as a consequence of the great deflections, and depends on the initial prestresses, strain diagram of the steel, strength and plasticity of the concrete, and type of load. Then, too, it is not possible to use a standard procedure in analyzing the ultimate strength of prestressed beams, as the author suggests. Regarding the choice of load factors, as it will be necessary to operate with random quantities, it is understood that theories should be formulated on a statistical basis; if not, every proposed system will be merely the result of guesswork. C. A. Sciammarella, Argentina

1085. **Mühe, D., Tension in prestressing steel due to variable friction** (in German), *Beton u. Stahlbeton* **50**, 10, 251–255, Oct. 1955.

Frictional force is separated into components due to curvature of prestressing steel or cable and friction in "straight" cable and this results in a Bernoulli differential equation. Solving this equation gives formulas which are discussed in some examples. Paper gives an interesting demonstration of effect of friction in prestressed concrete. A. Selberg, Norway

1086. **Stott, J. P., Prestressed concrete roads,** *Instn. civ. Engrs. Proc.* (II) **4**, 3, Road Paper no. 47, 491–538, Oct. 1955.

Use of prestressed concrete in roads has some limitations. Paper reviews the present applications and discusses many factors of importance which were little known previously, both advantages and disadvantages. Particular attention is paid to the formation, development, and significance of cracks. Continuous and individual slabs are investigated. Distribution of stresses

imposed by prestressing, traffic, temperature, and shrinkage is investigated, especially high tensile stresses which may be set up by subgrade restraint in a long slab during contraction. These stresses may partly or completely neutralize the prestressing, and the conclusion is made that the lengths of slag should not exceed about 400 ft. Experiments in this field are described. Examples show that prestressed-concrete roads are less expensive than concrete roads of orthodox type, considering the prospect of longer life. Suggestions are made on how to reduce unfavorable subgrade restraint. Many other important factors are thoroughly discussed, such as stability against buckling, sound aggregates, problem of creep, characteristics of pre- and post-tensioning.

List of 17 references is followed by valuable discussions by A. J. Harris, H. W. Dupree, A. R. Collins, W. E. I. Armstrong, W. P. Andrews, P. B. Morice, A. Goldstein, A. G. Tarrant, A. D. Ross, J. Mercer, J. R. A. D. Maule-ffinch, E. H. Cooley, and N. A. S. Fitch. J. J. Polivka, USA

1087. Berridge, P. S. A., and Easton, F. M., Some notes on the half-through type plate girder railway bridge, *Instn. civ. Engrs. Proc.*, part II, **4**, 3, 601–651 Oct. 1955.

1088. Norris, C. B., and Boller, K. H., Transfer of longitudinal load from one facing of a sandwich panel to the other by means of shear in the core, *For. Prod. Lab. Rep. U. S. Dept. Agric. Rep.* no. 1846, 17 pp. Apr. 1955.

A sandwich strip is loaded by forces applied at the ends of the face sheets. Through shear stresses in the core, part of the force applied to one face is transferred to the other so that ultimately both faces carry equal forces. Authors treat the core as a two-dimensional continuum, the faces as thin beams, including the string term (which makes the final result nonlinear). The elastic change of the core thickness is taken into account. The solution consists of three exponentials, two of which are dropped as unimportant. A check shows that they are exactly those which are caused by the thickness deformation.

Tests have been made and are compared with the theory.

W. Flügge, USA

1089. March, H. W., and Smith, C. B., Flexural rigidity of a rectangular strip of sandwich construction, *For. Prod. Lab. Rep. U. S. Dept. Agric. Rep.* 1505 revised, 18 pp. + 2 figs., Feb. 1955.

See AMR **6**, Rev. 1546.

1090. English, J. M., and Knowlton, C. F., Jr., Load test of a diagonally sheathed timber building, *Proc. Amer. Soc. civ. Engrs.*, Separ. no. 830, 25 pp., Nov. 1955.

A 200-ft by 50-ft diagonally sheathed frame structure, with bowstring timber roof trusses spaced 20 ft apart, was tested as to rigidity and strength to resist wind loads. The loading was limited to $1^1/_2$ times of the design wind-loading requirements of the location in Los Angeles County, Calif. Deformation and recovery diagrams are presented.

The observation was made that the rigidity and strength of the diagonally sheathed timber diaphragm were merely the integrate strength of the nails. Nowhere was the lumber loaded to more than a fraction of its ultimate strength. The brunt of the forces was transmitted by those structural components which provided maximum rigidity, such as sheathing boards without or with a small number of splices.

These observations, in full agreement with field experience in various structural fields, led the discusser to the suggestion to improve the rigidity and strength of wood joints by the use of improved (hardened plain or, even better, hardened threaded) nails. Such a procedure would allow savings of as much as one third of the framing lumber by spacing lumber studs 24 in. instead of 16 in. apart without decreasing, if not increasing, the rigidity and strength of the framed structure.

E. G. Stern, USA

1091. Anonymous, New plywood truss, *The Timberman* **57**, 3, 80–81, Jan. 1956.

A new type of bow-string truss is described. The lower chord and web members are made up of lumber. The upper chord consists of a continuous plywood panel serving simultaneously as roof sheathing. This exterior-type $^{13}/_{16}$-in. Douglas fir plywood panel consists of 4-ft wide sheets scarfed together to a length of 62 ft for a building of 60-ft span.

A 36,400-sq-ft warehouse using 360 of these roof trusses, at 24-ft centers, was recently erected at a total building cost of only $2 per sq ft as a result of the use of this economical roof construction.

Tests on a full-size truss showed its unusual stiffness. An ultimate load of 96.3 lb/sq ft was recorded. Spans up to 120 ft are considered practical for this outstanding type of construction.

E. G. Stern, USA

1092. Troche, A., Material requirements for nailed plate girders (in German), *Bauingenieur* **30**, 5, 185–191, May 1955.

Complete design data for nailed plate girders, with diagonal web members in single planes and in same direction, were derived in mathematical form and some of them presented in a quadruple nomographic chart. Total lumber requirements for such girders, as based on German standard specifications, can be directly read from this chart. Total nail requirements can be determined with the presented formulas.

The chart was prepared for conditions which exist when the design load is uniformly applied. For other loading conditions, substitutions can be arranged in the chart.

This presentation is an invaluable help to architects and engineers using nailed (not glued) plate girders of described web design. E. G. Stern, USA

1093. Bub, H., Research and investigation in wood constructions (in German), *Bautechnik* **32**, 11, 357–361, Nov. 1955.

Rheology, Plastic, Viscoplastic Flow

(See also Revs. 1009, 1036, 1037, 1058, 1061, 1064, 1065, 1070, 1082, 1108, 1130, 1322)

1094. Prager, W., Problems in plasticity theory [Probleme der Plastizitätstheorie], Basel, Birkhaüser Verlag, 1955, 100 pp. SFr 12.50.

This book is based upon a course of lectures given by the author at the Federal Polytechnic Institute in Zürich during November and December 1954. The book has been prepared with great care, and it constitutes a good introduction to a variety of aspects of current research in the mechanics of plastic deformation of metals. The range of topics is wide and reflects the major interests of the author and his associates at Brown University. The decision to limit the book very largely to the ground covered in the Zürich lectures has necessarily led to the exclusion of certain important topics. In particular, there is an absence of references to the physical foundations of plasticity and to dynamic plasticity and plastic stability, and the reviewer would like to have seen the inclusion of some, albeit brief, discussion of these important subjects. The content of the book is briefly summarized as follows:

Chap. I treats the mechanical behavior of plastic solids. The use of simple models to simulate the mechanical behavior of deformable bodies is applied to situations of gradually increasing complexity. The general theory of the von Mises plastic potential, including the case of generalized stress and strain rate, is presented for an elastic, perfectly plastic material. As an illustration, the theory is applied to the general problem of plastic plane stress for a plate made of material obeying either the von Mises or the Tresca yield condition and associated flow rule.

Chap. II concerns the mechanical behavior of structures in the plastic range. General ideas are introduced through the study of a simply indeterminate, pin-jointed truss composed of bars of elastic, perfectly plastic material. The plastic deformation of the truss is discussed in terms of geometry in a stress plane. Extremum principles are formulated, and the terms "load-carrying capacity" and "shake-down" are defined. Extensions of the analysis to highly redundant trusses and indeterminate beams are briefly considered.

Chap. III discusses the limit analysis of structures. The two fundamental extremum theorems and the interpretation of load-carrying capacity are discussed. Here, the relationship between the work of D. C. Drucker, H. J. Greenberg, and W. Prager, and of R. Hill is commented upon. The examples of a portal frame and a circular frame are first studied. The theory of circular plates and shells of revolution is then introduced, and some illustrative examples are solved. Increase in load-carrying capacity with progressive deformation is shown to occcur for a simply supported, circular plate under a central concentrated load. Finally, the application of the concepts of limit analysis to problems in building construction and soil mechanics is briefly indicated.

Chap. IV deals with finite plastic deformations. The general theory of the plane strain of rigid, perfectly plastic material is developed. As an illustration of various techniques, the following representative problems are considered: sheet extrusion, wedge indentation, deeply notched bar in tension, and tube drawing through a conical die. H. G. Hopkins, England

1095. Prager, W., Minimum weight design of plates, *Ingenieur* **67,** 48, 141–142, Dec. 1955.

A simply supported plate of arbitrary shape is subjected to a transverse load of given distribution and intensity. The plate is to be made of a rigid, perfectly plastic material that obeys Tresca's yield condition and the associated flow rule. The varying thickness of the plate is to be determined so that (a) loads of the given distribution but less than the given intensity do not produce plastic deformations of the plate, and (b) the weight of the plate is as small as possible. Problem leads to the solution of a certain boundary-value problem. The elliptical plate under uniformly distributed load is treated as an example. A membrane analogy is established, indicating the varying thickness of the plate of minimum weight. F. Chmelka, Austria

1096. Sanders, J. L., Jr., Plastic stress-strain relations based on linear loading functions, *Proc. second U. S. nat. Congr. appl. Mech.*, June 1954; Amer. Soc. mech. Engrs., 1955, 455–460.

The stress-strain relations of incremental theories of plasticity have recently been generalized by the use of any number of loading functions instead of only one [AMR **7,** Rev. 779]. Present paper is concerned with incremental theory based on any number of linear loading functions. In this case, the resulting plastic strain increments are integrable in a restricted sense and the stress-strain relations can be given in a form partially resembling deformation theories. The slip theory of Batdorf and Budiansky falls within the class of theories which are discussed in this paper.

From author's summary by W. T. Koiter, Holland

1097. Lee, E. H., and Wang, A. J., Plastic flow in deeply notched bars with sharp internal angles, *Proc. second U. S. nat. Congr. appl. Mech.*, June 1954; Amer. Soc. mech. Engrs., 1955, 489–497.

Previous solutions by Lee [AMR **7,** Rev. 1470] for progressive plastic deformation of tension bars with rectangular or V-notches were based on the hypothesis that the sharp angles persisted. This is only possible if a crack opens up to form a new portion of external surface. In the present paper, another type of solution is described in which no fresh surface is formed and the radius of curvature at the root increases steadily. Authors compare the two solutions in considerable detail but do not arrive at any definite conclusion as to which is to be preferred. Authors do not, however, highlight the full seriousness of the nonuniqueness difficulty; an *infinite* number of different solutions and deformation patterns are theoretically possible according to present knowledge. R. Hill, England

1098. Hopkins, H. G., On the behaviour of infinitely long rigid-plastic beams under transverse concentrated load, *J. Mech. Phys. Solids* **4,** 1, 38–52, Oct. 1955.

Author treats title problem under assumptions of thin-beam theory. Impact velocity may vary in time (with certain restrictions) and the motion following unloading is also treated. Solutions involve a fixed yield hinge at point of impact and two lateral, outward-moving yield hinges. The beam does not come to rest in any finite time. Reviewer thinks paper a clear, well-detailed treatment of an important case of rigid-plastic motion. F. C. Roesler, England

1099. Craemer, H., Orthogonally reinforced rectangular slabs subjected to hydrostatical load according to the plasticity theory (in German), *Öst. Bauzeitschr.* **10,** 8/9, 167–170, Aug./Sept. 1955.

The theory is developed after the ideas of Johansen (theory of the lines of rupture); in the rupture stage, the slab is supposed to take the form of a roof. The results are obtained by means of the virtual work method. The two cases solved are: (1) The plate simply supported on four sides; (2) the plate simply supported on three edges. Ch. Massonnet, Belgium

1100. Drucker, D. C., On obtaining plane strain or plane stress conditions in plasticity, *Proc. second U. S. nat. Congr. appl. Mech.*, June 1954; Amer. Soc. mech. Engrs., 1955, 485–488.

Paper gives short superficial discussion of geometric conditions necessary to obtain plane plastic strain. Conclusion that specimen thickness must be rather large compared with important dimensions in the plane is well known to all who have experimented in this field. The only precise evidence offered by author which tends to this conclusion is an approximate calculation for one special case, viz., a 90° V-notched bar in tension. This provides an undoubtedly very low bound of 2:2 for the requisite ratio of specimen thickness to width of reduced section.

R. Hill, England

1101. Feigen, M., Inelastic behavior under combined tension and torsion, *Proc. second U. S. nat. Congr. appl. Mech.*, June 1954; Amer. Soc. mech. Engrs., 1955, 469–476.

Experiments were conducted on four 24S-TS aluminum tubes, one-in. OD, under combined tension-torsion where the axial stresses varied from 11,000 to 58,000 psi while the shear stresses were always small, maximum order of 650 psi. SR-4-type AR-1 45° rosette wire strain gages were formed into circuits to measure only axial strains in one case and, in the other, to measure only shear strains. Author was not entirely successful in using SR-4

gages beyond 15,000 microinches. Results obtained using Riehle testing machine are not consistent with those from constant-load machine to check effect of constant load. Complete agreement was not reached with the flow theory of Onat and Drucker or with the deformation theory of Peters, Dow, and Batdorf as used in plastic buckling of plates. Author reports that a specimen which is tensile-stressed into plastic region exhibits no plastic shear strain under small torsional stress; but under a steady small shear stress, plastic shear strains occur when axial strain is increased. Upon removal of torsion stress after the occurrence of plastic shear, specimen exhibits plastic untwisting when axial strain is increased. H. Majors, Jr., USA

1102. Rhines, F. N., Bond, W. E., and Kissel, M. A., Grain-boundary behavior in creep of aluminum bicrystals, *NACA TN* 3556, 56 pp., Dec. 1955.

The gliding of one metal crystal with respect to another parallel to their mutual grain boundary has been studied in pure aluminum bicrystals during isothermal creep at temperatures ranging from 200 to 650 C under static stresses of 10 to 1600 psi. The motion is spasmodic and begins with an induction period. Its direction is determined by that of the maximum resolved shearing stress in the plane of the grain boundary, but its rate depends as well upon the angle through which the active slip systems are bent as they cross the grain boundary, being the higher the greater the distortion at the grain boundary. The over-all gliding rate is a linear function of the cube root of time and bears an Arrhenius relationship to the temperature; and its logarithm is proportional to the stress, over small ranges of stress. Shearing occurs within a zone of finite thickness, which becomes thicker with time, increasing temperature, and increasing stress. The metal within this zone is composed of subgrains that rotate back and forth about an axis which is sometimes the octahedral axis of the parent crystal. Rupture, which is never intergranular, is preceded by a sudden increase in the rate of uniform extension in one of the crystals. The mechanism of grain-boundary gliding is described as a coordinated alternation of slip and recovery in a chain of subgrains along the grain boundary. This concept is employed to account both for the rate of primary creep and for the transition from primary to steady-state creep.

From authors' summary

1103. Kennedy, A. J., The physical and computing significance of an electrical analogue of creep and recovery, *Brit. J. appl. Phys.* **6,** 2, 49–58, Feb. 1955.

Method similar to passive element analog computer is described which, on the basis of short-time creep experiments, can predict performance of sample in long-time experiments. The short-time experiments are necessary to determine constants for computing experiment. But information as to how this constant is to be applied to design a specific circuit is lacking.

Reviewer believes that, in the absence of a strict mathematical proof, author stretches conclusion in part unduly.

Some of the computer techniques, e.g., current integration, are useful as well in other analog computers.

V. Paschkis, USA

1104. Pawlowski, J., Generalization of Helmholtz's principle (in German), *Kolloid Z.* **138,** 1, 6–11, Aug. 1954.

Generalization of the Helmholtz principle (of least work applied to steady Newtonian flow) is developed for the flow of incompressible, inelastic, non-Newtonian liquids for which the tensors of deformation rate and stress deviation are coaxial and similar. A relationship with earlier (theoretical) phenomenological investigations is established.

In the argument, author finds it necessary to postulate that viscosity is a function of the second invariant but not of the third invariant of the tensor of the deformation velocity. Without disparaging this work, reviewer points out that most, if not all, non-Newtonian liquids are also thixotropic; and local viscosity varies with past history as well as with local deformation velocity. Hence theory would apply to steady-state flow in Couette viscometer but not rigorously to steady extrusion through capillary of finite length. M. Mooney, USA

Failure, Mechanics of Solid State

(See also Revs. 1058, 1094, 1101, 1102, 1132)

1105. Schijve, J., and Jacobs, F. A., Fatigue tests on notched and unnotched clad 24S-T sheet specimens to verify the cumulative damage hypothesis, *Nat. LuchtLab. Amsterdam Rap.* M. 1982, ii + 32 pp., 25 figs., 11 tables, Apr. 1955.

Report describes experiments in tensile fatigue to investigate Miner's hypothesis that $\Sigma n/N = 1$, where n is actual cycles at given stress level and N the cycles to failure at that level. Tests were carried out with zero minimum stress and two different levels of maximum stress. Three sets of results reported are for: (1) low prestress and high test stress; (2) high prestress and low test stress, both with range of prestress cycle ratios n/N from 2% to 50%; and (3) alternate blocks of high and low stress with cycle ratios of 5%. For every test condition, 10 test pieces were used of 24S-T alclad plate, 2 mm thick for unnotched, and 5 mm thick for notched test pieces.

Results show effect of cladding on fatigue life is generally unfavorable. Cumulative cycle ratios greater than 1 are recorded for all tests except the low prestress tests on unnotched plate. Some statistical analysis of results is made.

Authors are aware of testing with very simple load spectrum and that disadvantages of using an unstable precipitation hardened alloy may restrict general applicability of results.

C. E. Turner, England

1106. Smith, C. R., Prediction of fatigue failures in aluminum alloy structures, *Proc. Soc. exp. Stress Anal.* **12,** 2, 21–28, 1955.

A method is described of predicting finite fatigue life of (aircraft) parts having a given theoretical stress-concentration factor and loading condition. It is based on an extrapolation from empirical data such as static stress-strain curves and S-N diagrams.

The main assumption is that, whenever the product of the mean applied tensile stress and the stress concentration factor exceeds the yield strength of the metal, the excessive stress is relieved by localized plastic flow and a residual (compressive) stress is set up in the yielded region.

As an illustrative example, the method is applied to predict the fatigue behavior of a solution heat-treated and cold-worked duralumin (24S-T3) in the form of a flat coupon with a round hole. Predicted and experimental figures are compared and the advantages, limitations, and sources of error are discussed.

N. H. Polakowski, USA

1107. Zeitlin, E. A., Allowable stresses for thin metal structural elements at elevated temperatures, *Proc. Soc. exp. Stress Anal.* **12,** 2, 29–44, 1955.

Typical elastic constants at elevated temperatures are summarized for 18-8 steel, Inconel X, and titanium. Curves displaying the variation of several effective moduli with stress are given. Analysis charts relating plate dimensions and column slenderness ratio with typical allowable stresses in compression for 18-8 steel,

Inconel X, titanium, and aluminum alloys at several temperatures are presented for the plastic and the elastic ranges. Results of a stress analysis and a static test at 850 F of a typical built-up, simply supported I-beam of 18-8 steel sheet are given and discussed. From author's summary by G. Gerard, USA

1108. **Turner, F., The service life of aircraft structures. An examination from a statistical viewpoint of the fundamentals upon which aircraft stressing is based,** *Aircr. Engng.* **26,** 306, 260–263, Aug. 1954.

The ultimate aim of the stress calculation of aircraft structures is to reduce the frequency of defects in service to an acceptably low level. If this is to be done without undue structure weight, the design loads, the factors of safety, and the allowable stresses must be chosen with great care. In principle, there must be some relation between the probability of failure and the design strength. On a new design this function is always unknown and the designer must rely on experience of previous aircraft to guide his judgment. However, the required service life and the expected conditions of service, including temperature effects, vibration, etc., must be foreseen and taken into consideration. The variability in strength of new or old materials in new conditions must also be considered. From author's summary

1109. **Haas, T., Fatigue tests and aircraft life evaluation. On the experimental correlation of service endurance tests with fatigue tests at constant stress amplitude,** *Aircr. Engng.* **27,** 320, 334–337, Oct. 1955.

1110. **Jaklitsch, F., Residual life of machine parts following initial damage** (in German), *Motortech. Z.* **16,** 8, 227–239, Aug. 1955.

1111. **Priest, D. K., Beck, F. H., and Fontana, M. G., Stress-corrosion mechanism in a magnesium-base alloy,** *Trans. Amer. Soc. Metals* **47,** 473–492, 1955.

The mechanism of stress corrosion in the magnesium-base alloy J1) containing 6% aluminum, 1% zinc, and 0.2% manganese has been studied in a 3% NaCl—3% K_2CrO_4 solution at room temperature. All specimens were taken from $\frac{1}{2}$-in.-diam extruded rod. The effects on stress corrosion of heat treatment, grain size, lattice orientation, cathodic protection, and the pH value of the testing solutions were evaluated. Observations of crack propagation were made by means of a microscope located above the solution container. Motion picture microscopy of the cracking was accomplished and this proved to be an effective tool. A half-hour film on stress corrosion was prepared.

Specimens of small grain size, furnace-cooled from solution temperature, cracked intergranularly in stress-corrosion tests. Water quenching of specimens of small grain size resulted in transgranular stress corrosion. In specimens with grain sizes larger than ASTM no. 7, transgranular stress corrosion occurred regardless of heat treatment.

In contrast to stress-corrosion data previously reported for hard-rolled AM-C 57 S-H, an alloy having the same nominal composition as J1, the pH value of the salt-chromate testing solution had no effect on whether cracking was transgranular or intergranular in the annealed specimens used in this investigation. Heat treatment was the criterion for the type of failure which occurred.

Transgranular stress corrosion was found to take place along the (0001) plane of the HCP lattice of this alloy. This was determined by stereographic analyses of twin and crack traces on the surface of very large grained specimens.

Cathodic protection by means of an external current prevented the initiation of both transgranular and intergranular stress corrosion. It also stopped stress corrosion which was in progress.

The mechanism of transgranular stress corrosion is believed to be essentially electrochemical in nature because of the action of cathodic protection. Heidenreich, Gerould, and McNulty have shown that a segregation of cathodic FeAl exists in the solution-quenched condition of this alloy. The presence of this compound increases susceptibility to stress corrosion. This segregation appears to occur on only one plane. It has been shown in the present work that transgranular stress corrosion takes place predominantly along the basal plane. It is reasonable to state, then, that preferential attack occurs along the basal plane because of the presence of FeAl. The function of stress is believed to be that of exposing film-free metal by plastic deformation brought about by the stress concentration at the base of the crack. From authors' summary

1112. **Hodson, P., Influence of fine particles on corrosion of economizer and air-preheater surfaces by flue gases,** *Trans. ASME* **77,** 3, 279–286, Apr. 1955.

See AMR 7, Rev. 2646.

1113. **Huge, E. C., and Piotter, E. C., The use of additives for the prevention of low-temperature corrosion in oil-fired steam-generating units,** *Trans. ASME* **77,** 3, 267–278, Apr. 1955.

See AMR 8, Rev. 849.

Material Test Techniques

(See also Revs. 1019, 1020, 1121, 1242, 1295, 1298)

1114. **Chilver, A. H., The instability of testing machines,** *Instn. mech. Engrs. Proc.* **169,** 25, 407–418, 1955.

Paper deals with instability of both tension and compression testing machines. It is demonstrated that, under certain conditions which are commonly found in the testing of short columns, the stability of the machine itself is of great importance. Pictures of ingenious models are given, showing the shapes of buckling curves taken by testing machine members. A general stability equation is presented and extended to six common special cases. Comparison is made to previous work by Lundquist and Schwartz. Author treats only buckling of machine framework in the plane of the frame.

Discussion extends treatment to buckling out of plane of frame, showing that lower critical load values often occur for noncoplanar buckling. A simple energy method is applied and a good working relationship derived. It is concluded that instability can be avoided by careful design and layout of the testing machine. Reviewer feels this paper is important to those designing special types of testing machines and to anyone doing research on compression members. T. A. Hunter, USA

1115. **Lazan, B. J., Brown, J., Gannsett, A., Kirmser, P., and Klumpp, J., Dynamic testing of materials and structures with a new resonance vibration exciter and controller,** *Proc. ASTM* **52,** 858–876, 1952.

The characteristics of near-resonance vibration are discussed to clarify the relationships among resonance amplification factor, damping energy, and dynamic modulus of elasticity. A newly developed machine is described for exciting and controlling resonance or near-resonance vibrations in materials and joints under various types of stress. This machine imposes an adjustable-while-running mechanical exciting force at a controllable frequency, and, by means of automatic electronic controls, maintains the desired vibration phase angle and the desired magnitude of the excited force. This is done by controlling the frequency

and magnitude of the exciting force, respectively. Equations are developed for determining the resonance amplification and other properties from the machine readings. The stability and accuracy of the machine are discussed. Data are presented on the damping and elasticity properties of aluminum and mild steel, and these are compared with results procured in rotating cantilever beam equipment. The resonance response, damping, and elasticity properties of a bolted joint were determined, and the effects of bolt tension and molybdenum disulfide lubrication are illustrated and partially analyzed.

From authors' summary

1116. Jeffrey, J. O., and Hanlon, R. H., Bending and impact tests of cast-iron, cast-steel, and nodular-iron valve bodies, ASME Ann. Meet., Chicago, Ill., Nov. 13–18, 1955. Pap. 55—A-10, 6 pp., 1955.

Commercial standard 6-in. valve bodies were tested in bending at 900 F and under drop-impact tests at 40 F. Results indicate that ferritic iron valves possess sufficient shock resistance and ductility to avoid brittle fracture under these conditions.

From authors' summary

1117. Preston, D., Exploratory investigation of high-temperature sheet materials, *Proc. ASTM* **52,** 962–986, 1952.

The purpose of this project was to determine the high-temperature mechanical properties of several materials commercially available in sheet form. The materials investigated included three iron-base strain-hardening-type alloys, three iron-base age-hardening-type alloys, and three cobalt-base alloys which are used in the annealed condition. Microstructures are discussed, and creep, stress rupture, and short-time tension and yield data are presented for these alloys from room temperature to 1800 F.

From author's summary

1118. Vitman, F. F., Zlatin, N. A., Stepanov, V. A., and Shestopalov, L. M., Determination of mechanical properties of metals by means of a small conical impression and shallow scratch (in Russian), *Zh. tekh. Fiz.* **24,** 3, 388–399, Mar. 1954.

1119. Vitman, F. F., Zlatin, N. A., Ioffe, B. S., and Shestopalov, L. M., Determination of the mechanical properties of metals by means of small conical impressions and shallow scratches at elevated temperatures (in Russian), *Zh. tekh. Fiz.* **24,** 3, 549–559, Mar. 1954.

Mechanical Properties of Specific Materials

(See also Revs. 1063, 1074, 1091, 1092, 1093, 1105, 1106, 1111, 1116, 1117, 1118, 1119, 1239, 1242)

1120. Doerr, D. D., Compressive, bearing, and shear properties of several non-ferrous structural sheet materials (aluminum and magnesium alloys and titanium) at elevated temperatures, *Proc. ASTM* **52,** 1054–1078, 1952.

Paper describes briefly the program in which the compressive, bearing, and shear properties were determined for (1) 24S-T3 aluminum alloy at room temperature and elevated temperatures between 212 F and 700 F, with exposure periods ranging from 0.5 to 1000 hr; (2) 75S-T6 aluminum alloy, FS-1h and MH magnesium alloy at room temperature and at elevated temperatures ranging from 300 F to 600 F, for exposure periods between 0.5 and 1000 hr; and (3) annealed and cold-rolled titanium at room temperature and several elevated temperatures between 400 F and 1000 F, for exposure periods of 0.5 and 100 hr. These properties have been compared with the tensile data in an attempt to establish a possible correlation of the compressive, bearing, and shear characteristics with the tensile properties of the individual materials at elevated temperatures.

The test specimens, equipment, and procedures are described briefly. Test results in the form of curves illustrate the effect of temperature and exposure time on the physical properties of the various materials investigated. From author's summary

1121. Ronay, B., Clautice, W. E., and Erskine, W. F., Evaluation of the prototype unit for the ASME high-temperature steam generator investigation, ASME Ann. Meet., Chicago, Ill., Nov. 13–18, 1955. Pap. 55—A-63, 8 pp. + 6 figs., 1955.

The ASME Research Committee on High-Temperature Steam Generation is concerned with the evaluation of materials as superheater tubing for the temperature range of 1100 to 1500 F. One phase of this project concerns exposing tubes made of 17 different alloys to steam flow at 2000 psi and at various temperatures with the above given range. This report presents the test of the prototype portion of the final test equipment. This prototype was built to evaluate the design features of the various components and the reliability of the automatic control devices intended to serve the final installation.

From authors' summary

1122. Anonymous, Powder metallurgy makes better reactor fuels and components, *Nucleonics* **13,** 12, 24–26, Dec. 1955.

Techniques and advantages of powder metallurgy for reactor uses are presented in this summary. Better resistance to radiation and applicability to unusual combinations are two main reasons for high interest in these methods.

From summary

1123. Miller, D. C. R., The silicones, *Engng. J., Montreal* **38,** 10, 1339–1349, Oct. 1955.

A whole new family of substances, the silicones, have recently found their way into the rubber, plastics, plywood, aircraft, paint, electrical equipment, automotive, cable, hardboard, construction, clothing, footwear, baking, bottling, packing, and many other industries. Their uses are multiplying daily. The trend is toward increasing utilization of types which, combined with organic materials, may be used to upgrade their durability and extend their temperature range. From author's summary

1124. Werren, F., and Heebink, B. G., Interlaminar shear strength of glass-fiber-reinforced plastic laminates, *For. Prod. Lab. Rep., U. S. Dept. Agric.* no. 1848, 9 pp. + 5 tables, 3 figs., Sept. 1955.

This report presents the results of tests to determine the interlaminar shear strength of glass-fiber-reinforced plastic laminates. Eleven different types of laminates were tested to investigate the effect of (1) type of resin, (2) type of reinforcement, and (3) resin content on the interlaminar shear strength of laminates. About 165 shear tests were made after normal and wet conditioning and with loads applied at angles of 0° and 45°.

There was considerable variation in the test results, but the epoxide laminate made with Epon 1001 resin was consistently highest in interlaminar shear strength. Polyester laminates of 181 and 112 fabrics had higher shear strength than did similar laminates with reinforcements of 143 glass fabric or glass mats. A decrease in resin content of polyester laminates of 181 fabric appeared to result in lower shear strength at the 0° angle of load but higher shear strength at the 45° angle. In general, specimens tested after wet conditioning had somewhat lower shear strength than those tested after normal conditioning.

From authors' summary

1125. **Youngs, R. L., Supplement to bolt-bearing properties of glass-fabric-base plastic laminates,** *For. Prod. Lab. Rep., U. S. Dept. Agric. Rep.* no. 1284-B, 7 pp. + 2 tables, 10 figs., Oct. 1955.

1126. **Smoke, E. J., and Koenig, J. H., Industrial application of ceramics,** ASME Ann. Meet., Chicago, Ill., Nov. 13–18, 1955. Pap. 55—A-160, 6 pp. + 6 figs., 1955.

Ceramic products are defined as those made of inorganic minerals which are usually subjected to high temperatures during fabrication. This definition embraces a wide range of products; but, of more importance to the engineer, it embraces a wide range of unique properties. From authors' summary

1127. **Hansen, W. C., and Livovich, A. F., Factors influencing the physical properties of refractory concretes,** *Bull. Amer. ceram. Soc.* **34,** 9, 298–304, Sept. 1955.

Mechanics of Forming and Cutting

(See also Revs. 983, 1122, 1245, 1274, 1298)

1128. **Town, H. C., Hydraulic and pneumatic operation of machines,** New York, Philosophical Library, Inc., 1956, 192 pp. $7.50.

Part I of the book describes the advantages and limitations of oil for power transmission and shows the main types of pumps used. Circuit diagrams are included, and the applications to various types of machines, including machine tools and presses, are discussed. A chapter is devoted to the important and little-known advantages of the hydraulic rotary drive, and this is followed by features of the general design of cylinders, pipe lines, valves, and protection devices.

Modern accumulator systems are described, then hydrokinetic transmission. This chapter includes diagrams of fluid couplings and torque converters, with descriptions of their applications to the modern automatic gear-changing devices now coming into use on motor vehicles.

Part II, dealing with pneumatic developments, includes chapters on air compressors and structural details; the operation and maintenance of pneumatic tools; and the design of pneumatic circuits. The increasingly important subject of air-operated jigs and fixtures is discussed, followed by industrial applications of air control of brakes, clutches, conveyers, and aircraft components.

The book concludes with examples of hydropneumatic devices, dealing with oil control of air pressure, and describes circuit control design, tracer-controlled copying devices, and air-hydraulic feed units. From publisher's summary

1129. **Walker, W. F., Fundamentals of press tool design,** New York, Philosophical Library, Inc., 1955, 152 pp. $4.75.

Author's aim in this book is to identify and explain the fundamental requirements, which must be known and understood for each different press operation, so that tools efficient and economic in operation can be designed.

An instructive chapter on the cutting operation is followed by detailed information on the designing of tools for over twenty different press operations. The many variations of each operation are fully illustrated by a series of drawings.

Many hints on the finer points of press tool design are given.

The calculation of blank sizes is fully covered with the addition of worked examples of areas for noncircular parts.

In the final chapter, information is provided on the different tool materials suitable for the varying types of press tools, and advice is given on their suitability for different conditions and quantities.

The text is amplified by the addition of over 160 line drawings, ten tables, and numerous formulas.

From publisher's summary

1130. **Thomsen, E. G., Comparison of slip-line solutions with experiment,** ASME Ann. Meet., Chicago, Ill., Nov. 13–18, 1955. Pap. 55—A-51, 6 pp., 1955.

Theoretical solutions are presented for the mean pressures and the axial stresses which are developed in the axially symmetric extrusion of a perfectly plastic body. The solutions are obtained with the Hencky-Prandtl network of shear curves. The similarity between results obtained with the plane strain solution and an approximate three-dimensional solution obviates the need for the latter more difficult one.

To apply the solutions to the extrusion of aluminum, the flow stress is determined in a property test and the critical shearing stress is estimated with Tresca's criterion. Satisfactory agreement is obtained between the plane strain solution and experimental results which were obtained in an actual extrusion process. L. Mordfin, USA

1131. **Niedzwiedzki, A., The influence of the cutting speed, part I, II** (in French), *Alliance Industrielle, Belgium* **75,** Oct. 1954, p. 207; Dec. 1954, p. 245.

Author mostly reviews previous work on metal cutting. He points to influence of cutting speed on tangential force; interprets constants in Taylor's formula as factors on machinability of workpiece and kind of cutting tool used; and compares efficiencies of carbide compositions and high-speed steel.

M. Martellotti, USA

1132. **Nadeinskaia, E. P., Investigation of cutting tool wear by means of radioactive isotopes** (in Russian), *Izv. Akad. Nauk SSSR Otd. tekh. Nauk* no. 1, 24–40, Jan. 1954.

Hydraulics; Cavitation; Transport

(See also Revs. 1128, 1139, 1141, 1143, 1172, 1198, 1199, 1214, 1325, 1327)

1133. **Sutton, B. A., Formation of a hydraulic jump in a long uniform channel. Significance of the critical depth,** *Engineering* **179,** 4657, p. 532, Apr. 1955.

1134. **Vágás, I., Proof of model laws for decanting basins** (in Hungarian), *Hidrólogiai Közlöny* **9,** 10, 327–330, Oct. 1955.

It is shown that the Froude scaling law is applicable to Dortmund-type basins by performing experiments with two geometrically similar models at several volume rate-of-flow conditions. The proof follows from dimensionless presentation of the crossflow function. Allowing for a maximum error of 3.4%, the 4:1 tested scale ratio is covered by Froude's law.

Paper is clear presentation of sound ideas and experiments of limited range. V. G. Szebehely, USA

1135. **Dul'nev, V. B., Stationary nonuniform motion in an open nonprismatic channel of a given shape** (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **96,** 4, 705–707, June 1954.

The stationary nonuniform motion in an open prismatic channel was studied long ago—first by J. M. Bélanger, 1828; systematically by Bresse, 1860; then by many others; put in order by B. A. Bakhmeteff ["Hydraulics of open channels," McGraw-Hill Book Co.]. Reviewer does not know if a study for *nonprismatic* channels was done before that by the latter author.

Author generalizes for nonprismatic channels the differential

equation of steady, nonuniform motion. The limitation he introduces (trapezoidal cross section) is not essential and may be avoided in further studies. Two kinds of changes appear in the generalized equation: (1) "channel-characteristics" become variable along the flow axis without altering the form of the equation; (2) the second term of numerator becomes multiplied with a "variability factor" (μ).

Instead of 8 classical water profiles (5 backwater and 3 drop-down curves), the integration of the generalized equation supplies 8 for convergent channels and 16 for divergent ones (all but 3 supercritical backwater curves are represented in Figs. 1 and 2 by the author).

Next, author gives a practical method of approximate integration of his differential equation; reviewer has checked transformations involved. Author admits that profiles are sometimes complicated, presenting partly backwater, partly drop-down curves in the same profile; therefore, minute steps must be used in the integration process.

Reviewer wishes to add that the 24 profiles by the author are of different mathematical kind than the 8 classical ones; in a prismatic channel, any change of origin or of integration constant produces a simple displacement of the profile, hence the 8 classical profiles are *unique;* the 24 profiles by the author *change in shape* if origin or constant are changed, hence the complete solution would involve a *family* (field) of curves for each of the 24.

The problem is of practical interest and worthy of further studies.

No bibliographical references are given.

N. Krivoshein, Argentina

1136. Robinson, A. R., and Rohwer, C., Measurement of canal seepage, *Proc. Amer. Soc. civ. Engrs.* **81,** Separ. no. 728, 20 pp., June 1955.

1137. McLeod, E. B., Jr., The explicit solution of a free boundary problem involving surface tension, *J. rational Mech. Analysis* **4,** 4, 557–567, July 1955.

Author treats problem of finding the shape of a two-dimensional bubble having significant surface tension, in an incompressible irrotational flow which is uniform at infinity. Method consists of determining conformal transformation which maps the free boundary on to the unit circle, although author points out that the same results may be obtained from use of the variational technique devised by Schiffer. The problem is restricted in that a particular value of the bubble internal pressure was chosen to simplify the mathematics. In addition to the determination of the mapping function for the bubble, an outline is given of the application of the method to problems in which a bubble is attached to the ends of a fixed linear boundary segment.

L. Talbot, USA

Incompressible Flow: Laminar; Viscous

(See also Revs. 972, 1018, 1021, 1135, 1167, 1168, 1171, 1172, 1176, 1180, 1181, 1185, 1186, 1193, 1257, 1258, 1259, 1260, 1311, 1312, 1313, 1325)

1138. Torda, T. P., Thompson, W. J., and Genetti, B. K., Laminar incompressible mixing of two-dimensional and axially symmetric jets, *Proc. second U. S. nat. Congr. appl. Mech.,* June 1954; Amer. Soc. mech. Engrs., 1955, 715–721.

Von Karman integral technique is applied to the problem of viscous, laminar, incompressible mixing of two-dimensional and axially symmetric jets. For two-dimensional jets, the region just downstream of the "potential core" in which the effects of the upstream boundary layers are dissipated is considered. A closed form solution could not be obtained, but a special numerical example is presented.

The farthermost downstream of three regions of the mixing zone is treated for axially symmetric jets. The von Karman equations can be integrated for this case. S. Ostrach, USA

1139. Szebehely, V. G., Oscillatory motion of a spheroid, *Proc. second U. S. nat. Congr. appl. Mech.,* June 1954; Amer. Soc. mech. Engrs., 1955, 771–776.

Except for additional work on influence of free surface on hydrodynamic moment of inertia k, this paper contains essentially the same material as 1953 report by author and O. C. Niederer [AMR **7,** Rev. 1532] on unsteady effects on a prolate spheroid having major axis 9 feet in length and slenderness ratio 7. Free (yawing) oscillation experiments, at zero forward speed only, indicated no dependence of k on frequency or amplitude of oscillation for depth/diameter ratios varying from about 1/2 to 2. Value of k increases with decreasing depth up to highest Froude number F ($=\omega^2 L/g$; ω frequency, L length, g gravitational acceleration) of the experiments, 3.8. Author's comparison with reviewer's approximate solutions for $F = 0$ and $F = \infty$ [8th inter. Cong. appl. Mech., 1952] indicates applicability of rigid-wall ($F = 0$) solution over this range.

Damping, assumed to be governed by linear equation of motion, was found to vary with frequency and with amplitude. Since only free oscillations were used, k was assumed to be independent of speed and the zero-speed value used in deriving the damping. (More recently, experiments by Stallkamp [*Calif. Inst. Technol., Hydro. Lab. Rep.* E-35.4, Sept. 1955], employing forced oscillation techniques, show that k is markedly dependent on forward speed. In light of this, author's conclusions may require significant modification.)

Finally, author attempts to justify the form of equation of dimensionless damping as function of reduced frequency, which is used to fit the data, on the basis that equation will have the same general form for bodies of revolution as for wings of infinite aspect ratio. However, no physical arguments are presented in support of this hypothesis. P. Eisenberg, USA

1140. Arkhangel′skiĭ, V. A., Nonsteady-state flow of gasified oil solved by the method of steady-state change (in Russian), *Izv. Akad. Nauk SSSR Otd. tekh. Nauk.* no. 7, 133–145, July 1954.

Nonsteady-state flow of gasified oil is approximately solved by the method of finite differences and the method of steady-state change. Proof is given in two examples that the simple method of steady-state change gives identical results with the more laborious method of finite differences. The Arkhangel′skiĭ method assumes identical flow discharge of oil and gas through all planes of permeable soil during the computed interval. No verifying experiments are cited.

The article seems to reflect some controversy with other Russian methods, perhaps that of Carevich, K. A. [See the Russian textbook by Ščelkachev, V. N., and Lapuk, B. B., "Underground hydraulics," 1949, Gosmontechizdat Moskva, pp. 233–244 and 494.] Z. Bažant, Jr., Czechoslovakia

1141. Levin, L., Notes on the flow mechanics of water-air mixtures (in French), *Houille blanche* **10,** 4, 555–557, Aug.-Sept. 1955.

For the flow of water-air mixtures, the coefficient of frictional resistance is no longer a constant expression, as it is in classical hydraulics. However, its magnitude seems to tend toward a constant as the concentration of air in the emulsion increases. A new formula is suggested relating air concentration to the hydraulic characteristics of the canal.

From author's summary

1142. **Speidel, L., Calculation of flow losses in plane unstaggered cascades of airfoils** (in German), *Ing.-Arch.* **22**, 5, 295–322, 1954.

As part of a program at the Institute of Fluid Mechanics of the Technical University of Braunschweig for the development of a systematic procedure for the analysis of the flow through cascades of airfoils, this paper presents a detailed computational procedure for obtaining the flow of an incompressible viscous fluid through a plane unstaggered cascade of airfoils for the case in which the airfoils are of finite thickness. The procedure is similar to that of Schlichting and Scholz [AMR **4**, Rev. 3922] for the case in which the airfoils are of infinitesimal thickness. Pressure and velocity distributions on the airfoils are derived from the potential flow obtained by a singularity distribution procedure (source-sink and vorticity distributions to yield the airfoil shape), and the boundary-layer distributions are obtained by standard procedures. Loss coefficients and the change in the exit flow direction due to these boundary layers are then computed.

In order to study the effect of various cascade parameters on the flow, computations are carried through for a series of cascade configurations composed of NACA airfoils with various thickness and camber values and with various solidity ratio values. A good comparison is obtained between these computed values and some previously unpublished experimental results of N. Scholz.

P. Chiarulli, USA

1143. **Vladimirov, A. N., Approximate hydrodynamic design of a finite span hydrofoil** (translated from Russian, Central Aero-Hydrodynamical Institute, Rep. no. 311, 1937), *NACA TM* 1341, 68 pp., June 1955.

1144. **Lieber, P., Anderson, O., and Wan, K. S., On variational principles for real fluids,** Rensselaer Polytechnic Institute, Troy, N. Y., *OSR TN* 55-370, 35 pp., Oct. 1955.

Authors formulate a general variational principle to describe the motion of real fluids. Under restrictive conditions not given here, this principle is that the rate of dissipation of energy in the flow is a minimum, in agreement with work of Rayleigh and Korteweg. More generally, the principle is that the work done by traction applied at the surface be a minimum, the inertia and pressure forces being kept constant during the variation. The former principle is applied to compute the drag on a circular cylinder and the latter to determine the flow between parallel plates and to develop a boundary-layer theory. Curves are given for the velocity profile near the stagnation point of an elliptic cylinder and compared with experiment and Pohlhausen's theory.

H. C. Corben, USA

1145. **Tanner, L. H., Note on a null method for the direct measurement of pressure coefficients,** *Aero. Quart.* **6**, 4, 241–253, Nov. 1955.

Values of the pressure coefficient C_p between $+1$ and -1 can be measured directly in incompressible flow by comparison with the known pressures on a circular cylinder placed in the tunnel working section. The method gives more consistent and accurate readings than can easily be obtained with normal manometer measurements, particularly when the pressure differences are small and the tunnel speed not very steady. Possible ways of extending the range of coefficients which can be measured are suggested. From author's summary by A. Petroff, USA

1146. **Welanetz, L. F., A suction device using air under pressure,** ASME Ann. Meet., Chicago, Ill., Nov. 13–18, 1955. Pap. 55—A-38, 4 pp., 1955.

An analysis is made of the suction holding power of a device in which a fluid flows radially outward from a central hole between two parallel circular plates. The holding power and the fluid flow rate are determined as functions of the plate separation. The effect of changing the proportions of the device is investigated. Experiments were made to check the analysis.

From author's summary

Compressible Flow, Gas Dynamics

(See also Revs. 1164, 1169, 1173, 1178, 1183, 1190, 1221, 1222, 1229, 1275, 1285, 1305)

1147. **Dailey, C. L., Supersonic diffuser instability,** *J. aero. Sci.* **22**, 11, 733–749, Nov. 1955.

Main subject of paper is instability of flow that occurs in an axially symmetric supersonic air intake with central body, when operating at high subcritical mass flows. Wind-tunnel tests were made at $M = 1.95$ on a model with 20° conical central body. Fluctuating pressures on central body and in plenum were measured and recorded on oscillograph. Changes of inlet shock system were studied by taking short-duration schlieren photographs. After studying results and considering various alternative interpretations, author concludes that development of flow instability depends essentially on strong interaction between "subcritical" shock and boundary layer on central body. This causes intake flow to be cut off; pressure in plenum chamber then falls, and intake flow is restarted. Author emphasizes distinction between this instability, referred to as "buzz," and a high-frequency organ-pipe resonance observed at low mass flows. This high-frequency oscillation occurs during part of buzz cycle when shock is in front of intake.

Some further experiments showed that burning of fuel in the duct had no qualitative effect on the buzz. In most cases, the burner blew out immediately buzz started.

W. A. Mair, England

1148. **Dewey, P. E., and Vick, A. R., An investigation of the discharge and drag characteristics of auxiliary-air outlets discharging into a transonic stream,** *NACA TN* 3466, 38 pp., July 1955.

Authors present results of experimental investigation of force and discharge characteristics of rectangular and circular air outlets discharging from wind-tunnel wall into streams of Mach numbers 0.7 to 1.3. Discharge characteristics complement information presented in *NACA RM* L52A20 and *NACA TN* 3442 of elliptical and circular outlets. Dynamometer measurements of thrust of several outlets represent one of earliest attempts to obtain such data. Most important results are: Observed decrease of discharge coefficients of rectangular thin plate outlets with increasing aspect ratio; negligible effect of stream Mach number (over test range) on discharge coefficient of tested flush ducted outlets; high discharge coefficients of recessed outlets; measuring of thrust of inclined outlets approximates streamwise component of outlet ideal thrust. But, paradoxically, report states outlets discharging normal to stream also produced thrust at certain flow rates. Reviewer believes this is due to streamwise deflection of outlet flow by main flow.

Reviewer feels report is valuable for large amount of data presented, which covers subject adequately and substantiates conclusions. H. L. Bloom, USA

1149. **Wegener, P. P., Water vapor condensation process in supersonic nozzles,** *J. appl. Phys.* **25**, 12, 1485–1491, Dec. 1954.

Experimental and theoretical investigations of water-vapor condensation phenomena in supersonic nozzles are reviewed. It is shown empirically, for a given experiment, that the shocklike disturbance visible in flow pictures delineates the collapse of the

supercooled state of the water vapor present in the air. All flow properties are calculated through this extended condensation zone from pressure distribution measurements, and it is seen that no shock waves are involved in the process. Finally, a conversion of these data to an equivalent constant-area flow reveals that the latter would be an example of a weak detonation observed in nature, as predicted by Burgers and by Reed.

From author's summary by J. L. Harkness, USA

1150. Watson, W. G., Nozzle flow with heat transfer and friction. One-dimensional expansion of a compressible fluid in a convergent nozzle with heat flow and friction, *Aircr. Engng.* **27,** 320, 339–345, Oct. 1955.

Paper contains a one-dimensional analysis of the flow of a compressible fluid through a nozzle in which the effect of friction is supposed to be approximated by assuming that the expansion follows the law $pv^n = \text{const}$, the index $n \neq \gamma$ remaining constant through the expansion considered.

This is yet another attempt to revive a discredited assumption which is neither confirmed by experiment nor by the more exact theory in which the essentially two-dimensional character of the flow is taken into account (friction confined to boundary layer, the core being isentropic). It leads to the usual difficulties which author attempts to circumvent by arguments of questionable validity.

Reviewer already took issue with the usefulness and validity of the assumptions on which the analysis in the paper is based [see Kestin and Owezarek, AMR **5,** Rev. 805, quoted by author]. The simpler, one-dimensional theory in which the effect of the boundary layer is replaced by a shearing stress at the wall has been described by Kestin and Zaremba [AMR **8,** Rev. 547, not quoted by author]. J. Kestin, USA

1151. Gundersen, R., One-dimensional flow of a perfect fluid with slightly variable entropy (in French), *C. R. Acad. Sci. Paris* **241,** 15, 925–927, Oct. 1955.

Perturbation equations defining a given one-dimensional isentropic unsteady flow subjected to weak disturbances are formulated. Simple results are shown to exist when the given flow is either uniform or a simple wave flow, and when the disturbances are both isentropic and nonisentropic. It is stated that the method is being used for the study of unsteady flows in channels of slowly varying cross sections. G. M. Lilley, England

1152. Latter, R., Similarity solution for a spherical shock wave, *J. appl. Phys.* **26,** 8, 954–960, Aug. 1955.

Author analyzes point source, spherical shock flow considering dissipation at an infinitely strong shock. Solution is of similarity type described by Taylor [AMR **4,** Rev. 1381) for zero dissipation. Form of dissipative term q agrees with Richtmyer and von Neumann requirements [AMR **4,** Rev. 775]. Although a specific form of q is used to obtain detailed results, analysis is general and can be applied to other forms of q, providing they admit of a similarity solution.

An analytic solution is obtained for the region, $0 \leq x = (r/R) \leq 1$, in which $q = 0$. R defines the position of the Taylor shock front. This solution is identical to Taylor's. A finite difference solution is obtained for the region, $1 \leq x \leq \infty$ in which $q \neq 0$.

Author is careful to point out that specific q chosen may produce inconsistencies in the solution. For q used in author's work, the Rankine-Hugoniot relation is not satisfied across the shock as it is in the Richtmyer-von Neumann solution for the plane shock. In addition, to introduce q into the equations for $x \geq 1$, slope discontinuities in the physical variables must be admitted, leading to possible inaccuracies in the finite difference solution.

Equations are solved for increasing amounts of dissipation, characterized by increasing values of the constant K appearing in the expression for q. As K increases from 0 to 0.349, the density ratio across the shock decreases from 6 to 1.137.

H. E. Brandmaier, USA

1153. Mahony, J. J., A critique of shock-expansion theory, *J. aero. Sci.* **22,** 10, 673–680, 720, Oct. 1955.

Shock-expansion theory for the calculation of the pressure distribution on thin sharp-nosed two-dimensional airfoils in a supersonic stream assumes that the shock waves which attach to the leading edge are of uniform strength, whereas for all sections in which the surface is curved near the leading edge, the shock will decay due to the expansion waves generated by the airfoil. Moreover, for high Mach numbers it is not possible to use the fact that the entropy change is of the third order in the stream deflection to deduce that the effects of vorticity behind the shock are small. To investigate this matter, author examines the hypersonic case by means of the analogy due to Hayes and Goldsworthy in which the airfoil problem is compared with the one-dimensional motion of a gas due to a prescribed motion of a piston. Author gives a comparison between the pressure distributions as calculated by their methods: simple wave solution, shock-expansion theory, and the method of this paper. The two latter methods give very close results, even when the quantities included by shock-expansion theory are no longer small. An asymptotic form is given for the decay of the leading-edge shock which is valid for shocks too strong for the Friedrichs theory.

G. Temple, England

1154. Bernstein, B., and Thomas, T. Y., The differential equations of the stream lines for compressible gas flow, *J. rational Mech. Analysis* **4,** 5, 703–719, Sept. 1955.

Neglecting the viscosity and thermal conductivity, a system of two differential equations giving the direct determination of the streamline pattern is obtained for the two-dimensional steady compressible gas flow. The velocity components are then replaced by the inclination ω of the streamlines and the quantity $G = m^2 - 1$, m being the local Mach number. The condition of integrability of the system of equations thus obtained gives a cubic equation in G with scalar differential functions of ω as coefficients, which enables us to express G as an algebraic function of ω and its derivatives. By eliminating G, authors then arrive at a system of two (not fully independent) nonlinear differential equations in the single dependent variable ω. Either equation can be taken as the equation to determine the streamline pattern, the remaining one imposing only an additional boundary condition.

The solution of the Cauchy problem for the streamline pattern is given, and characteristic curves are discussed and determined, which give, respectively, the streamlines and those curves making an angle μ ($= \text{arc sin } 1/m$) with the streamlines. Finally, the formal solution is presented of the problem of determining the streamline when the data are given along the contour of an obstacle or airfoil. S. Tomotika, Japan

1155. Seth, B. R., New formulation of equations of compressible flow, *Bull. Calcutta math. Soc.* **46,** 4, 217–220, Dec. 1954.

Author transforms equation of continuity for an irrotational, steady, compressible flow into a new, much simpler equation (one new variable times the Laplacian of the second new variable is equal to the second variable times the Laplacian of the first). One new variable is the square root of the density. The other new variable is the product of the velocity potential and the square root of the density.

The new equation has many particular solutions which can be

found easily. Reviewer feels new equation should be kept in mind especially when one attempts to find solutions for contour surfaces of coordinate systems for which Laplace's equation is separable. K. M. Siegel, USA

1156. Meyer, R. E., and Mahony, J. J., Analytical treatment of two-dimensional supersonic flow; part I, Shock-free flow, *Aero. res. Lab., Melbourne, Austral. Rep.* no. A. 93, 56 pp. + 7 figs., Apr. 1955.

A solution is presented for the general, wave-interaction problem of steady irrotational, homentropic flow of a perfect gas. It can be interpreted as a convergent process of successive approximations, based on the solution of linearized theory, for shock-free flow. It constitutes an approximate solution for flow with weak shocks.

In part I, the equations of motion are transformed into linear equations in characteristic variables. Their solution is of different type according to whether the flow is near-sonic, hypersonic, or in between these extremes. Special attention is given to the types of boundary condition which occur in physical problems, and the solution methods are devised to cope with these types in the medium Mach number range. The method of Riemann functions is used to calculate accurately the pressure distribution in the first interaction region of a jet expanding from a perfect nozzle. It is shown by the help of double power series that shock waves will always occur in the first "period" of such a jet, even for pressure ratios arbitrarily near unity. The Riemann function approach is also shown to be suitable for the approximate calculation of the flow past airfoils of prescribed shape; when the requirements of accuracy are exacting, the method of double power-series expansion presents the problem in a form suited to high-speed digital computers.

From authors' summary by M. H. Bertram, USA

1157. Ferri, A., Vaglio-Laurin, R., and Ness, N., Mixed-type conical flow without axial symmetry, *Polyt. Inst. Brooklyn Rep.* 264, 29 pp. + 15 figs., Dec. 1954.

Conical flow fields containing both hyperbolic type and elliptic type regions are considered. Typical examples of such mixed flows are the flow about a cone at a nonvanishing angle of attack or the flow about a conical body of wing type with a sharp leading edge. The scope of the present paper is a detailed analysis of mixed flows about triangular wings with sharp supersonic leading edges at zero angle of attack, without the assumption of linearized theory. In this case a shock wave separates the undisturbed flow from the flow affected by the body. The supersonic region contains a part (transonic region) that is influenced by the elliptic part. Authors investigate this transonic region and the sonic lines separating the transonic region from the other parts of the flow field from a mathematical and a physical point of view. A procedure for practical calculation of the hyperbolic region by the method of characteristics is outlined, and methods for analyzing the elliptic region are discussed. No numerical results are given. Analytical details are to be described in further reports. The present paper only summarizes the results.

R. Sauer, Germany

1158. Germain, P., New applications of Tricomi solutions to transonic flow, *Proc. second U. S. nat. Congr. appl. Mech.*, June 1954; Amer. Soc. mech. Engrs., 1955, 659–666.

Calculations of compressible two-dimensional flow are based on theory from previous papers by author and associates. Three applications are made: (1) wedge at sonic stream velocity; (2) wedge in subsonic stream with free streamlines issuing downstream from base of wedge; and (3) jet with sonic velocity along free streamlines. Calculation method is approximate and involves elegant mathematical development throughout. Results for wedge in sonic stream yield disturbance pressures roughly 25% greater than earlier calculation of Guderley. Drag of wedge in subsonic flow is roughly 50% higher than calculations of Cole and of Guderley and Yoshihara. Method inherently is not restricted to small disturbances, but, when applied to small disturbances, yields results in conformity with transonic similarity rules. D. R. Chapman, USA

1159. Goethals, R., and Ménard, M., Contribution to the study of a lifting wing in compressible flow (in French), *Publ. sci. tech. Min. Air, France* no. 299, 207 pp., 1955.

Author considers rectangular wings of various aspect ratios in subsonic flow. Results are given of tests with wings of section NACA 65010, chord 120 mm, incidence $-2°$ to $+10°$, Mach numbers 0.3 to 0.875. C_L, C_D, C_m, and spanwise distribution of loading are plotted. Results are compared with those given by linearized theory for subsonic flow using various particular cases of the affine transformation. A unique empirical curve (based on experimental data) is obtained relating lift-curve slope to aspect ratio for Mach numbers up to 0.75.

A. W. Babister, Scotland

1160. Sears, R. I., and Merlet, C. F., Flight determination of the drag and pressure recovery of an NACA 1-40-250 nose inlet at Mach numbers from 0.9 to 1.8, *NACA TN* 3218, 30 pp., July 1955.

An investigation has been made with rocket-propelled models in free flight to determine the external drag and pressure recovery of the NACA 1-40-250 nose inlet at zero angle of attack. The Mach number range of the tests was from 0.9 to 1.8 and the corresponding Reynolds numbers based on body diameter varied from 4×10^1 to 10×10^6. A technique was developed for varying the internal air flow during flight so that the drag and pressure-recovery characteristics were measured as functions of both mass-flow ratio and Mach number. A pointed parabolic-arc body having the same contour as that of the inlet model aft of the inlet region was also tested to serve as a basis for drag comparison.

The test results indicate that, for mass-flow ratios greater than 0.6 and Mach numbers less than 1.14, the external drag of the inlet model was less than that of the parabolic-body model. At higher Mach numbers, the external drag of the inlet model increased rapidly relative to that of the parabolic-body. At a Mach number of 1.8 and a mass-flow ratio of 0.9, for example, the external drag of the inlet model was 50% greater than that of the parabolic-body. The total-pressure recovery at a mass-flow ratio of 0.80 exceeded that for an external-compression supersonic inlet up to a Mach number of about 1.3.

From authors' summary

1161. Bolten-Shaw, B. W., and Zienkiewicz, H. K., The rapid, accurate prediction of pressure on non-lifting ogival heads of arbitrary shape, at supersonic speeds, *Aero. Res. Counc. Lond. curr. Pap.* no. 154, 44 pp. + 14 figs., June 1952, published 1954.

Approximate methods, which reduce considerably the required computing time, are developed for determining the pressure distribution on nonlifting heads of arbitrary shape in irrotational supersonic flow. The basis of this method rests on the simple proportionality (shown by the authors in an earlier report) which exists in supersonic flow over a wide range of circular arc profiles and free-stream Mach numbers, between the decrease in pressure from the nose to a point P on a circular arc ogival body and the decrease in pressure from the leading edge of a two-dimensional air foil of the same profile to the same point P. This correspondence law is written $(P_N - P_P)$ axisymmetric $= (P_N - P_P)$ two-dimensional, where P_N, the surface pressure behind the nose shock

wave, is the same in both cases (this applies also to M_N, the Mach number behind the nose shock). λ, a constant, depends only on the free-stream Mach number and profile geometry and is reproduced in this report from earlier work.

In order to extend this work to bodies of arbitrary, continuously varying radius of curvature, it is assumed that λ varies continuously also and that the flow in expanding along the profile from a point P to an adjacent point Q expands as if the body were replaced by the ogive of curvature at P (i.e., the ogive generated by the revolution about the axis, of an arc of the circle of curvature at P). These assumptions, along with the correspondence relation stated above, permit the step-by-step determination of the pressure coefficient along the body once the conditions behind the nose shock wave are specified. Step-by-step solutions for three different head shapes were computed by this method and compared with second-order theory; good agreement was obtained.

By noting from empirical reasoning that the ratio of the local static pressure to the free-stream static pressure at a point P on an arbitrary convex head at a free-stream Mach number M is the same as at P on the ogive of curvature at the same free-stream Mach number, a simpler method termed the "ogive of curvature method," is developed wherein the pressure on any ogive head is calculated from the known pressures on the ogive of curvature. A modification to this method, employing the data of *NACA TN* 2250, is also presented.

This report presents interesting and certainly simple methods for determining the pressure distribution on nonlifting ogival heads satisfying the limitations stated. Reviewer feels that some of the assumptions need further consideration; the choice of expansion along ogives of curvature at any point stems from correspondence between the pressure on a circular arc airfoil and a circular arc ogival body, and is arbitrary, as stated by the authors. It would be of interest to know whether the λ-correspondence can be proved for other than circular arc profiles; if so, then a more direct approach not involving the assumption of expansion along ogives of curvature could be obtained. Presumably the authors will be treating these points in their future reports, referred to in the addendum to the present work. G. V. Bull, Canada

1162. Potter, J. L., Murphree, W. D., and Shapiro, N. M., On the normal force produced by multifinned tail assemblies in supersonic flow, *J. aero. Sci.* **22,** 7, 511–513, July 1955.

Although reasonably satisfactory methods have been devised for the calculation of normal forces on tail assemblies having two equally loaded fins 180° apart, very little progress has been made toward solution of the corresponding multifin problem where four or more fins may be acting. Two reports dealing with the subject have come to the attention of the authors. The earliest of these is by Luther and Jaeger and contains experimental results for several families of four-, six-, and eight-fin tails. The second report, by Miles, is a theoretical analysis using slender-body theory. The latter report includes generalized results and apparently represents the only study of its type. However, the limitations of slender-body theory are such that the writers, while appreciating the value of this work, wished to study the problem further. For this reason, it was decided that a brief but systematic supersonic tunnel program would be conducted for the purpose of obtaining additional experimental data on the lift of multifinned tail assemblies and that this would be followed by an attempt to generalize the data in a form suitable for design purposes. This note presents the data obtained thus far and a tentative proposal for an interference parameter which successfully correlates all the experimental data by Luther and Jaeger as well as that secured by the authors' experiments. From authors' summary

1163. Munk, M. M., Remarks on the velocity of sound, *J. aero. Sci.* **22,** 11, p. 795 (Reader's Forum), Nov. 1955.

Author emphasizes lack of identity between square of sound velocity and partial derivative of pressure with respect to density. He demonstrates this lack of identity for case of incompressible fluid with variable density and for compressible gas flows. In former case, derivative exists and is finite, yet sound velocity is infinite. For second case, sound velocity appearing in characteristic equations bears no relation to isentropic derivative.

O. K. Mawardi, USA

Wave Motion in Fluids

(See also Revs. 1010, 1136, 1156, 1290)

1164. Manabe, D., and Ohira, H., Two-dimensional characteristics of shallow water waves, *J. Japan Soc. aero. Engng.* **3,** 17, 1–6, June 1955.

The shallow water channel is often applied to the investigation of high-speed air flow. But the behavior of the shallow water wave is not exactly the same as that of the shock wave in air. This is due to the essential difference of both properties and boundary conditions between the air and the water. This paper presents the information on the two-dimensional characteristics of shallow water waves. Assuming that the disturbance is small, the expression for wave pattern is analyzed, and the effects of the scale, the water depth, the surface tension, and the velocity are explained. They are compared with the findings of the experiments.

Reviewer notes that the paper of Bömelburg [AMR **8,** Rev. 2786] on the same topic should also be of interest.

From authors' summary by S. D. Nigam, India

Turbulence, Boundary Layer, etc.

(See also Revs. 1135, 1144, 1185, 1215, 1254)

1165. Marris, A. W., Fluid turbulence and suspended sediment, *Canad. J. Technol.* **33,** 6, 470–493, Nov. 1955.

Paper deals with distribution of suspended sediment over depth of a very wide river. The well-known formula of Rouse ["Fluid mechanics for hydraulic engineers," McGraw-Hill, 1938] and experimental results are discussed as an opening. The discrepancy of exponents required for confirmation of the formula leads author to attempt a more complex analysis. For this, author uses equations analogous to turbulent heat transfer. Assumptions of infinitely fine sediment and a linear concentration gradient along length of stream at the bed are required. The velocity distribution is split into zones in which the velocity defect law, the laminar-boundary-layer law, and a buffer law describe the flow. Resulting equation relates the concentration at any point to a reference concentration of the bed. It is more complicated than the formula of Rouse, but, like the latter, predicts a more uniform concentration than found in experiments. To surmount the assumption of a concentration gradient, author applies approximate correction to predict the physical case of constant lengthwise concentration. It is shown that this correction has a very small effect on the over-all flow. The total suspended sediment load is computed and expressed as a function of the concentration at the bed. From this it is shown that the mean concentration occurs at 0.65 of the stream depth.

Reviewer believes that lack of adequate experimental confirmation will limit usefulness of the analysis. Ideas expressed should be helpful to workers in the research field.

W. D. Baines, Canada

1166. Mawardi, O. K., On the spectrum of noise from turbulence, *J. acoust. Soc. Amer.* **27,** 3, 442–445, May 1955.

The generation of sound from turbulent flow fields has become important by the extended use of jet propulsion for aircraft. Paper gives a short review of general equations for sound generation derived from Navier-Stokes equations. The turbulent flow field is assumed to consist of elements of a certain size inside of which the correlation of velocities at different points is one, and outside of which it is zero. Accordingly, the acoustical model for sound generation consists of quadrupoles whose oscillations are uncorrelated. The sound spectrum of a quadruple of spherical shape is investigated and found to have a maximum where the product of wave number and sphere radius is equal to one. However, the analysis is carried no further and no comparison with experiments is given. H. Schuh, Sweden

1167. Agostini, L., and Bass, J., The theories of turbulence [translation of **"Les théories de la turbulence,"** *Publ. sci. tech. Min. Air. France* **237,** 1950], *NACA TM* 1377, 163 pp., Oct. 1955.

See AMR **4,** Rev. 358.

1168. Weinstein, A. S., Osterle, J. F., and Forstall, W., Momentum diffusion from a slot jet into a moving secondary, ASME Ann. Meet., Chicago, Ill., Nov. 13–18, 1955. Pap. 55—A-60, 7 pp.

Measured mean velocity profiles in this turbulent flow show good agreement with the empirical postulate of Reichardt [*VDI-Forschungsheft* (*B*) **13,** May-June 1942].

In reviewer's opinion, the authors' attempt to draw an analogy between this shear flow and scalar diffusion in a homogeneous turbulence is without foundation. S. Corrsin, USA

1169. Davies, D. R., Heat transfer from a flat plate through a turbulent boundary layer, *Quart. J. Mech. appl. Math.* **8,** 3, 326–337, Sept. 1955.

This theoretical treatment of heat transfer through a turbulent boundary layer on a flat plate assumes similarity of temperature and velocity profiles and proportionality of the eddy-diffusion coefficients for momentum and heat. The results are compared with measurements by Elias [*ZAMM* **10,** p. 1, 1930] of heat transfer and temperature profiles, with good agreement if the eddy diffusivities for momentum and heat are everywhere equal. It should be noted that the assumed type of similarity is only valid over a range of comparatively small Reynolds numbers. Outside this range (which is nearly the range of validity of the $-1/5$ power law of frictional resistance), the details of the analysis would need modification. A. A. Townsend, England

1170. Craya, A., and Milliat, J.-P., Study of turbulent flow in a divergent channel (in French), *C. R. Acad. Sci. Paris* **241,** 7, 587–590, Aug. 1955.

Spectral distributions of the longitudinal turbulence velocity have been measured at different points in a section and in different sections of a slightly divergent channel (total angle of divergence 2°). From these one-dimensional spectra, Taylor's dissipation scale λ has been determined. With λ as characteristic length for the turbulence, results show that the Reynolds number of turbulence varied only slightly for the different points. The spectra could be made to group closely around a single curve if plotted in nondimensional form against $k_1\lambda$ (k_1 wave number). Dissipation showed maximum at points close to wall and minimum at points roughly 0.4 half-width distance from the wall.

Reviewer's note: The spectral distribution at the point closest to the wall showed in the medium wave-number range the spectral law k_1^{-1}, which, according to Tchen [AMR **6,** Rev. 3155], indicates a strong interaction between the vorticities of the main motion and those of the turbulence in this wave number range.

J. O. Hinze, Holland

1171. Helmbold, H. B., Note on velocity fluctuations in equilibrium turbulent shear flow along solid boundaries, *J. aero. Sci.* **22,** 7, 513–514, July 1955.

1172. Levin, A. M., Hydraulic jump and separation of boundary layers (in Russian), *Dokladi Akad. Nauk SSSR* (*N.S.*) **96,** 6, 1121–1124, June 1954.

Author studies separation phenomena accompanying the hydraulic jump. He uses a new parameter (Γ) deduced from well-known boundary-layer properties, and affirms separation and counterflow or rollers *must appear always* when $\Gamma > \Gamma_{cr}$ (>0) (italics by reviewer).

Author emphasizes the importance of analogy between pressure-gradient $\partial p/\partial x$ under water and surface-slope $\partial z/\partial x$ in the free surface. Two expressions for Γ correspond hereto; with the first, author explains bottom and side separation; with the second, surface rollers on the jumps.

In the first case, reviewer agrees with author; in the second, he believes surface rollers can appear in two manners: (a) as a propagation of a side separation, in which case author's criterion is valid; (b) as a spontaneous cusp wreck of an undulated (or growing direct) jump, which phenomenon does not obey the "Γ-criterion" but *other rules*. Reviewer has made observations of cusp wreck of waves and is preparing a paper on it.

Then, specially for open channels, author gives a third (approximate) expression for Γ having $1 - Fr$ in denominator (Fr = "square" Froude number). $\Gamma = \infty$ when $Fr = 1$, i.e., when flow passes from torrential to tranquil (Γ great but not ∞ when surface curvature is regarded). From this viewpoint, author's example about bottom rollers beneath wave crests of an undulated jump is well-founded, but the above italic words *must* and *always* may be viewed as absolute only when skin friction is involved. Hereto reviewer can propose a counterexample: an undulated bore (advancing jump) where, due to absence of boundary layer, no bottom rollers await. In that case no rollers appear at all, and the whole dissipated energy passes to the wave motion.

Author's experimental observations of *jumps in tranquil* flow seem to be novel and reviewer believes them of great practical interest, especially for aerodynamical laboratories which use hydraulic analogy for supersonic flow; such jumps may occur in the model where no shock waves in the prototype are present. Author observed tranquil-flow jumps (undulated and direct) with $Fr = 0.4$ to $Fr \infty 0.8$ and says they appear because of the great local surface slope and of the nonhydrostatic pressure distribution. Therefore, reviewer means such tranquil-flow jumps may appear only in narrow deep channels; hence aerodynamical laboratories must use *wide shallow channels* for hydraulic analogy, to avoid "false shock waves."

Three publications in Russian are cited by the author.

N. Krivoshein, Argentina

1173. Li, T.-Y., and Nagamatsu, H. T., Similar solutions of compressible boundary-layer equations, *J. aero. Sci.* **22,** 9, 607–616, Sept. 1955.

The partial differential equations for the compressible laminar boundary layer are transformed into a system of ordinary differential equations by a direct method. This new method yields explicitly an equation which allows similar solutions. The hypersonic viscous flow over a flat plate is discussed as an example of similar solutions. The characteristics of the laminar boundary-layer flow with pressure gradient and heat transfer were obtained

on a Reeves electronic analog computer. It is shown that, on a heated plate, the local velocity inside the boundary layer can exceed the free-stream value when a certain pressure gradient exists, and that the effects of heat transfer on the laminar separation phenomenon can be studied quantitatively.

R. C. Binder, USA

1174. Simon, P. C., and Kowalski, K. L., Charts of boundary-layer mass flow and momentum for inlet performance analysis, Mach number range 0.2 to 5.0, *NACA TN* 3583, 32 pp., Nov. 1955.

Mass flow and momentum for various fractions of a turbulent boundary layer are presented in chart form for a range of velocity profiles and for Mach numbers from 0.2 to 5.0. These charts are intended to assist the analyst and designer of boundary-layer removal systems. Application of the charts to inlets of arbitrary shape and to the determination of the pressure recovery of rectangular, normal-shock inlets immersed in boundary layer is described. From authors' summary

1175. Meksyn, D., Integration of the boundary-layer equations for a plane in compressible flow with heat transfer, *Proc. roy. Soc. Lond.* (*A*) **231,** 1185, 274–280, Aug. 1955.

The equations of motion for the compressible boundary-layer flow past a flat plate with zero pressure gradient are integrated. Problem is solved by expanding the velocity and temperature in power series in $\eta = y(U_1/\nu_1 x)^{1/2}$, the usual "similarity parameter," and retaining only the first terms in the series. This results in expressions whose radius of convergence is small, particularly for wall temperatures considerably smaller than free-stream temperatures. Author does not, unfortunately, give quantitative limits on the regime of usefulness of the results, although he does indicate good agreement with previously published results for sufficiently high wall temperatures.

The work may be useful from the standpoint of the extremely simple results which are derived for the temperature and velocity distributions and the drag coefficient. W. Daskin, USA

1176. Watson, E. J., Boundary-layer growth, *Proc. roy. Soc. Lond.* (*A*) **231,** 1184, 104–116, July 1955.

Work presented here is an extension of that of Blasius [AMR **3,** Rev. 2011] on boundary-layer growth at a cylinder started from rest. It is shown that if an infinite plane moves in its own plane in a viscous fluid, the velocity distributions are similar at different times if the velocity $V(t)$ of the plane is of the form $V(t) = At^{\alpha}$ or $V(t) = Ae^{\alpha t}$, where t is the time. These cases are then applied to the theory of boundary-layer growth, and the second approximation to the velocity in the boundary layer is calculated. From this is found a first approximation for the distance traveled by the cylinder before separation starts. The second approximation to the separation distance was calculated by Blasius for $\alpha = 1$, by Goldstein and Rosenhead [*Proc. Camb. phil. Soc.* **32,** 392–401, 1936] for $\alpha = 0$, and is found here for the case $V(t) = Ae^{\alpha t}$. Another approximate method for finding the separation distance, when separation starts in the rear stagnation point, is developed and applied to the impulsive start. The method is based on the momentum equation and assumes that the velocity profile near the rear stagnation point will always be similar to an initial profile.

Numerical results are presented in tables and include the variation with α of the separation distance (according to the first approximation). From author's summary by A. Ritter, USA

1177. Flügge-Lotz, I., The computation of the laminar compressible boundary layer, *Stanford Univ., Dept. Mech. Engng.*, June 15, 1954.

A difference method is developed for computing shear stress and temperature in the boundary layer as functions of the coordinate x along the wall and the velocity u parallel to the wall. Pressure gradient and temperature distribution along the wall are given continuous finite functions of the coordinate x. Density and viscosity coefficient depend on the local temperature in the boundary layer. The method is tested in regions of pressure decrease and pressure increase. The influence of the pressure gradient on skin friction and heat transfer is shown in different examples.

From author's summary by T. P. Torda, USA

1178. Low, G. M., Stability of compressible laminar boundary layer with internal heat sources or sinks, *J. aero. Sci.* 22, 5, 329–336, May 1955.

Paper is concerned with a third method of cooling surfaces of high-speed aircraft and missiles. The possibility of heat sinks within the boundary layer as a method of cooling these surfaces (instead of transpiration cooling or surface cooling from the interior) is investigated analytically by essentially extending the analysis of Chapman and Rubesin [AMR **3,** Rev. 2732] to include the effect of heat sinks in the energy equation. The assumptions made are not restrictive and the results are presented in the form of a comparison between the amount of heat that must be absorbed by sinks in the boundary layer to that which must be removed by surface cooling to achieve the same surface temperature. The advantages of the proposed method depend on the basis of comparison with other proposed methods. The author makes several different comparisons and suggests as a possibility the combined use of surface cooling and use of the surface coolant, latter as heat sinks in the boundary layer. He finds that boundary-layer stability by heat removal if sinks are used is not limited to Mach numbers less than 9 [AMR **6,** Rev. 2311]. Author briefly discusses mechanical problems of the "sink" method of surface cooling. R. S. Wick, USA

1179. Gault, D. E., An experimental investigation of regions of separated laminar flow, *NACA TN* 3505, 12 pp., Sept. 1955.

When the laminar boundary layer separates from an airfoil and subsequently reattaches as a turbulent layer, the region enclosed between the free layer and the surface is known as a laminar separation "bubble." Paper describes measurements defining a large number of bubbles of length small compared with the airfoil chord. Ultimate purpose was to determine conditions controlling occurrence and extent of such short bubbles.

Total- and static-pressure surveys, hot-wire observations, surface pressure, and liquid film measurements were made on two airfoils for wide ranges of incidence and Reynolds number.

Results confirm the finding of Owen and Klanfer [*R.A.E. Rep. Aero.* 2508, Oct. 1953] that a necessary condition for the formation of a short bubble is that the boundary-layer Reynolds number at position of separation must exceed a certain critical value. Author claims condition is insufficient. The boundary layer thickness at the position of separation and the boundary-layer Reynolds number were found to be the primary variables determining the extent of laminar separated flow, but the upstream pressure gradient also seems important. The laminar portion of the bubble varied from 75 to 85% of the total bubble length for all bubbles near the airfoil nose. An increase in free-stream turbulence reduced the extent of laminar flow in a manner analogous to an increase in Reynolds number. D. C. Collis, Australia

1180. Morghen, K., and Rothe, K., Boundary-layer suction with the aid of exhaust jet (in German), *Z. Flugwiss.* **3,** 11, 371–373, Nov. 1955.

Experiments with an exhaust jet pump consisting of a jet engine fitted with a mixing tube were carried out on the jet-

engine test bed of the Instituto Aerotécnico Córdoba in 1950, as suggested by Prof. K. Tank. It was intended to provide information to the airplane designer regarding the possibility of removing the boundary layer by means of the exhaust jet, i.e., the dimensions of the mixing tube as a function of the mass of air subjected to suction and the change in the effective thrust had to be found. From authors' summary

1181. **Smith, A. M. O., On the growth of Taylor-Görtler vortices along highly concave walls,** *Quart. appl. Math.* **13,** 3, 233–262, Oct. 1955.

Taylor-Görtler vortexes are streamwise vortexes having alternate right- and left-hand rotation that may develop in laminar boundary layer along a concave surface. The equations of motion are derived anew and re-examined with regard to the importance of various terms. The final equations are found to be valid for radii of curvature as small as 30 times the boundary-layer thickness. Furthermore, it is shown that the equations are not restricted in velocity to cases of constant wall curvature, constant free-stream velocities, or to boundary layers of constant thickness.

The solution is an eigenvalue problem, which has been solved mainly by Galerkin's method—a variational method. A second method is believed to offer considerable improvement, provided a high-speed digital computer is available.

A chart is prepared for computing the vortexes. In this chart the eigenvalues are also given. The chart is applied to all known experimental data concerning the effect of curvature on transition point. A new parameter as indicator of this point is proposed.

From author's summary by T. R. Gullstrand, Sweden

Aerodynamics of Flight; Wind Forces

(See also Revs. 991, 997, 1142, 1145, 1161, 1162, 1192, 1194, 1216, 1217, 1258, 1293)

1182. **Ludwig, R., Contribution to the nondimensional method of performance analysis for jet aircraft** (in German), *Z. Flugwiss.* **3,** 6, 141–150, June 1955.

Paper presents the modifications required to apply nondimensional performance analysis techniques to jet aircraft. A generalized drag polar is developed and combined with simplified jet thrust and fuel consumption equations to give performance data in level flight, glide, climb, ceilings, range, and endurance.

H. P. Liepman, USA

1183. **Grant, F. C., The proper combination of lift loadings for least drag on a supersonic wing,** *NACA TN* 3533, 21 pp., Oct. 1955.

Method of Lagrange multipliers is used to find the combination of a given set of lift loadings which gives minimum drag for a given total lift. The results yield an integral form of the criterion of R. T. Jones. The method is illustrated using four nonsingular loadings on a delta wing with subsonic leading edges.

H. Yoshihara, USA

1184. **Davis, D. D., Jr., The problem of reducing the speed of a jet transport in flight,** *NACA TN* 3613, 22 pp., Dec. 1955.

The distance required to decelerate a high-speed jet transport from the normal operating speed to the design speed for maximum gust intensity (rough-air speed) has been calculated for the case of level flight with the engines idling. This distance was found to be much greater for a jet transport than for a typical piston-engine transport at the same altitude, and the distance was found to increase with altitude up to the altitude for maximum true air speed. Because the increased distance for the jet transport was primarily a result of increased kinetic energy and, to a lesser extent, of lower drag coefficients, these results are believed to be qualitatively correct for high-speed transports in general. The exact distance for any particular airplane will, however, depend on the values chosen for the normal operating speed and for the rough-air speed (because these speeds control the kinetic energy that must be dissipated during deceleration) and also will depend on the airplane and engine characteristics.

The use of aerodynamic brakes, thrust reversal, or a climbing maneuver is shown to be effective in reducing the distance required to reach the rough-air speed, and therefore the use of such devices seems advisable. Even with the aid of such devices, however, the deceleration distance, at the altitude where it reaches a maximum, is likely to be considerably greater for jet transports than for the present-day piston-engine transports.

From author's summary

1185. **Wortmann, F. X., Contribution to the design of laminar profiles for gliders and helicopters** (in German), *Z. Flugwiss.* **3,** 10, 333–345, Oct. 1955.

Article deals with the problem whether, for a profile with given transition point, the drag can be reduced by changing the velocity distribution in the range of turbulent boundary layer. Theoretical investigations indicate that the turbulent boundary layer is very sensitive to the velocity profile in the range of adverse pressure gradients and that a velocity distribution with decreasing deceleration is desirable. Three different profiles have been calculated for $R = 10^6$. One is a conventional laminar profile, the other two are so-called "combination profiles." The latter are characterized by the fact that the drag coefficient remains small over a wider range of the lift coefficient, with emphasis on higher angles of attack. The theoretical studies are compared with experiments. The test results, however, do not quite come up to expectation. It is concluded that theory has to be refined and that the new profiles developed should be considered as a first step in the right direction. As theoretical studies presume satisfactory stability of the laminar boundary layer, i.e., small Reynolds numbers, the new profiles would be suitable for rotary wing aircraft, gliders, and windmills. G. J. Sissingh, USA

1186. **McCullough, G. B., The effect of Reynolds number on the stalling characteristics and pressure distributions of four moderately thin airfoil sections,** *NACA TN* 3524, 24 pp., Nov. 1955.

Low-speed measurements of the lift, drag, pitching moment, and pressure distribution of the NACA 0008, 0007.5, 0007, and 0006 airfoil sections are presented for Reynolds numbers from 1.5 to 6 million. It is shown that the flow over these airfoil sections changed from the type which precedes leading-edge stall to the type which precedes thin-airfoil stall at some lift coefficient which depended on the Reynolds number and on the airfoil thickness ratio. An increase of either of these two variables increased the lift corresponding to the flow change until, for the thicker sections at least, maximum lift was attained before the flow change occurred. It is possible, therefore, for airfoil sections in a certain range of thickness ratios to stall with either the thin-airfoil or leading-edge type of stall, depending on the Reynolds number. For the NACA 4-digit family of airfoils, there were no abrupt variations of maximum lift accompanying the change of stall.

From author's summary

1187. **Whitten, J. B., Reeder, J. P., and Crim, A. D., Helicopter instrument flight and precision maneuvers as affected by changes in damping in roll, pitch, and yaw,** *NACA TN* 3537, 14 pp., Nov. 1955.

The effects of increased damping in roll, pitch, and yaw on the

flying qualities of a single-rotor helicopter for precision flight have been studied by means of visual maneuvers and instrument approaches. Electronic components were used to vary the damping by producing control inputs proportional to rate of roll, pitch, and yaw in a direction to oppose the angular velocities.

The results indicate that, for a representative single-rotor helicopter, increased damping can reduce random deviations from the desired flight path and can decrease the effort required of the pilot, especially at low forward speeds. Increased damping in roll was found to be particularly beneficial; corresponding changes in yaw and pitch, however, were less effective for the combinations of parameters covered.

Some operational aspects of helicopter instrument approaches are also included in the discussion.

From authors' summary

1188. Herb, H., Flight performance of multiengine airplanes following the failure of one motor (in German), *Z. Flugwiss.* **3,** 11, 377–382, Nov. 1955.

1189. Miele, A., General solutions of optimum problems in nonstationary flight (translated from Italian), *NACA TM* 1388, 25 pp., Oct. 1955.

See AMR **7,** Rev. 877.

Aeroelasticity (Flutter, Divergence, etc.)

1190. Hunn, B. A., On the determination of the flutter forces on wings with supersonic leading edges, *Quart. J. Mech. appl. Math.* **8,** 3, 293–310, Sept. 1955.

Author transforms surface integral for velocity potential for purely supersonic wings into a polar form which is suggested for use in determining flutter forces. Reviewer believes subject matter has been more extensively treated in a number of papers, among which are *NACA TN* 2467 [AMR **5,** Rev. 1144] by Chieh-Chien Chang; and, for example, the article by S. Pines, J. Dugundji, and J. Neuringer [*J. aero. Sci.* **22,** 10, 693–700, Oct. 1955] and several of its references. H. C. Nelson, USA

1191. Watkins, C. E., and Berman, J. H., On the kernel function of the integral equation relating lift and downwash distributions of oscillating wings in supersonic flow, *NACA TN* 3438, 43 pp., May 1955.

Authors derive, under usual linearized considerations, downwash at a point due to arbitrary pressure distribution, employing method of doublet distribution. Result is an integral equation whose kernel function is, without proper mathematical treatment, singular or indeterminate within area of integration. Report then separates kernel, or aerodynamic influence function, into singular portion, which is properly evaluated, and a nonsingular portion, which can be numerically tabulated. Results are reduced, for comparison, to two-dimensional case, sonic case, and horseshoe vortex model.

Purpose of report is to provide the basis for a systematic, though laborious, method for approximate determination of unsteady lift distributions on arbitrary planforms in supersonic flow. Work is extension of similar formulation for subsonic flow by same authors and by reviewer. Related approach using source distribution is under development at M.I.T. Aeroelastic Laboratory, Republic Aviation Corp., and Chance-Vought Aircraft Corp. All are unfeasible without use of high-speed computing devices. H. M. Voss, USA

1192. Shevloff, N. P., The evaluation of flutter characteristics in design, *Aircr. Engng.* **26,** 306, 252–257, Aug. 1954.

1193. Chang, C.-C., and Chu, W.-H., Flow through a cascade in flapping oscillation, *Proc. second U. S. nat. Congr. appl. Mech.*, June 1954; Amer. Soc. mech. Engrs., 1955, 617–621.

"In a uniform flow a cascade of flat-plate airfoils is subject to small flapping oscillation, and is treated analytically with conformal mapping technique. Normal force and moment are given essentially in closed forms. The interference effects among the cascade airfoils are so significant that the usual approximation with single-airfoil theory is questionable. An example is given to demonstrate this point. The wake interference is expressed in ratio of hypergeometrical functions involving parameters, such as reduced frequency and gap-chord ratio. As the gap goes to infinity, it reduces to Theodorsen's function as a special case."

The method with conformal mapping technique has the advantage of the closed analytical form, but it limits the modes of oscillations among the blades to the special case where all blades are synchronized (that is, the relative distance between the blades is unchanged). Thus, in reviewer's opinion, the present paper is interesting from the point of view of introducing conformal mapping to the case of oscillating cascade, but the practical result is only a special case of a more general approach, given by Sisto (see reviewer's discussion of "Unsteady aerodynamic forms in cascade," *J.A.S.*) who reaches the conclusion that this type of interference most probably cannot be assumed to be the cause of actual vibration problems in axial-flow compressors.

J. R. Schnittger, Sweden

1194. Van de Vooren, A. I., Mathematical methods for calculating wing divergence and aileron effectiveness of elastic wings, *Nat. LuchtLab. Amsterdam Rap.* no. F. 160, 28 pp., 1955.

Homogeneous integral equations of which the lowest characteristic value determines the wing divergence speed or the aileron reversal speed have been derived. The characteristic function is equal to the wing twist. The accuracy of Galerkin approximations, introducing assumed twist functions and yielding the divergence or reversal speed, is discussed. Formulas for the aileron effectiveness and for the control force to be exerted by the pilot are presented. The methods are valid for all wing planforms and all speeds, the only assumption made being that of linearized aerodynamic theory.

From author's summary by L. Wilson, USA

1195. Hunn, B. A., A method of calculating the normal modes of an aircraft, *Quart. J. Mech. appl. Math.* **8,** part I, 38–58, Mar. 1955.

To calculate flutter speeds of aircraft, it is first necessary to calculate the mode of vibration. This mode is generally obtained in terms of some of the aircraft normal modes. A simplified method of calculating the free space normal modes of the aircraft was previously proposed by the author and successfully applied. Present paper presents some amplification and justification of technique, though a general justification is not attempted. Various points are illustrated by numerical examples.

From author's summary by A. A. Schy, USA

Propellers, Fans, Turbines, Pumps, etc.

(See also Revs. 1016, 1058, 1121, 1147, 1180, 1182, 1218, 1225, 1232, 1251, 1253, 1279, 1282, 1300, 1301, 1302, 1303)

1196. Burrill, L. C., The optimum diameter of marine propellers: a new design approach, *N.E. Cst. Instn. Engrs. Ship. Trans.* **72,** part 2, 57–82, Dec. 1955.

Author makes use of the vortex blade-element theory to examine the problem of the optimum diameter of marine propellers.

For homogeneous flow conditions good agreement is found with standard-series data. The problem is then discussed for the radially variable wake flow prevailing behind single screw hull forms, and it is found that a material reduction of diameter is favorable to propulsive efficiency. This result is known from experimental work by Van Lammeren and Van Manen carried out in the Netherlands Ship Model Basin, but it finds here its analytical confirmation. Curves obtained theoretically are presented, enabling the designer to find optimum solutions without reference to propeller charts. L. Troost, USA

1197. **Rogallo, V. L., and Yaggy, P. F., On the calculation of the 1·P oscillating aerodynamic loads on single-rotation propellers in pitch on tractor airplanes,** *NACA TN* 3395, 28 pp., May 1955.

The title of this paper may be expanded to read, "The calculation of the oscillating thrust loads which occur one cycle per revolution on single-rotation propellers in pitch on tractor airplanes." Authors state that these loads are induced as a result of propeller thrust axis inclination and/or asymmetries of the flow field in which the propeller operates. A simple computational procedure is presented to predict the oscillating thrust loads in terms of the upflow angles at the horizontal center line of the propeller disk. The latter may also be obtained by computational methods, thereby eliminating the need for experimental flow surveys. A comparison of the simple procedure with more elaborate calculations, using all the flow field characteristics measured for several wing-nacelle-fuselage combinations, shows good agreement. R. L. Bisplinghoff, USA

1198. **Van Aken, J. A., and Tasseron, K., On the effect of the shape of the blade section on the efficiency of backing marine propellers,** *Inter. Shipbldg. Progr.* **2,** 14, 453–457, 1955.

Four screw models are discussed in connection with "backing." The following results are obtained:

1. The "stopping power" of propellers with blade sections having shock-free entrance, i.e., propellers with hollow-faced profiles, is considerably less than in the case of propellers the greater part of whose blade sections have been designed with flat faces.

2. In proportion as the mean lines of the blade sections show more pronounced deflection (concave), the fall in efficiency increases with propellers turning backwards.

3. The fall in efficiency "backwards" of propellers with blade sections having asymmetrical mean lines is somewhat less than in the case of blade sections with symmetrical mean lines.

4. In comparing the open-water-screw efficiency "backwards," and "ahead," at equal values of the advance coefficient Λ, with the virtual pitch ratio determined experimentally at $S = 0$, there proves to be very fair agreement between the average decrease in efficiency and the decrease in efficiency and the decrease in virtual pitch ratio.

5. Optimum stopping power is obtained with lens-shaped blade sections, i.e., sections having straight mean lines; the open-water-screw efficiency "backwards" will then be equal to the open-water-screw efficiency "ahead." From authors' summary

1199. **Denny, D. F., An experimental study of air-entraining vortices in pump sumps,** *Instn. Mech. Engrs.* Preprint, 13 pp., 1955.

These experiments were carried through since 1950 at the British Hydromechanics Research Association Laboratory mostly with small suction pipes (1 to 4 in.) to determine the critical submergence (given in suction-pipe diameters) above which no air is entrained, as a function of the flow rates and various sump configurations and dimensions. These latter include width of sump, back-wall distance, approach channel location relative to the sump, clearance of suction bell to sump bottom. Some favorable parameters and arrangements are shown, but these are only qualitative for the prototype for single unit or a station with two or more, because no model laws could be established.

Reviewer prefers Iversen's and Fraser's representation [AMR **7,** Revs. 261, 260] that bases sump parameter on the diameter of the suction bell, which, or even its use or absence, is here in many cases not specified. A. Hollander, USA

1200. **Cornell, W. G., The stall performance of cascades,** *Proc. second U. S. nat. Congr. appl. Mech.,* June 1954; Amer. Soc. mech. Engrs., 1955, 705–713.

A theory is developed for the stalled performance of two-dimensional cascades, the blades of which are idealized as infinitesimally thin flat plates. The free streamline theory of incompressible, potential flow is used to predict the characteristics of the separated wakes and the jets between them. Constant momentum mixing of the wakes and jets is postulated and the over-all exit flow predicted. Both diffusing and expanding cascades are considered, showing interesting differences in behavior. Experimental data compare well with the results for cascade solidities in excess of unity.

The present theory appears to give a reasonable means of predicting performance of high-solidity cascades of slender, slightly curved profiles in the completely stalled regime. . . . Using the present results (theory) along with more completely understood analytical and experimental results for the unstalled range, off-design performance predictions for axial-flow compressors and turbines can be made more physically realistic.

From author's summary by A. S. Andes, USA

1201. **Van Le, N., Optimum stage for axial flow turbines,** *J. aero. Sci.* **22,** 7, 503–504, July 1955.

The problem of finding the stages of an axial-flow turbine that would run at the highest efficiency under prescribed pressure ratio, diameter, speed, and mass rate of flow has been approached on a trial basis, guided by experience. A solution to this problem is presented, aiming at a systematic investigation, eliminating the cut-and-tried process, and introducing possible use of computing equipment. From author's summary

1202. **Johnson, R. M., Closed systems for testing compressors,** ASME Ann. Meet., Chicago, Ill., Nov. 13–18, 1955. Pap. 55—A-157, 9 pp. + 3 figs., 1955.

The closed system is discussed in its broad applications to the shop testing of centrifugal and displacement compressors. The essential requirements for the design and operation of test systems to use various gases are reviewed. Instrumentation and procedures necessary to meet the ASME Power Test Codes standards of accuracy are considered in detail. Suggestions are made for code revisions needed to bring closed-system testing more fully within the scope of the test codes.

From author's summary

1203. **Jaski, F. E., Field-testing a reversible pump-turbine,** *Mech. Engng., N. Y.* **78,** 2, 141–144, Feb. 1956.

Flatiron Power and Pumping Plant unit delivers efficiencies of 91% pumping and 88.8% generating.

From author's summary

1204. **Emmons, H. W., The turbomachinery compressor (Forum on Hydraulics),** *Mech. Engng., N.Y.* **77,** 12, 1056–1058, Dec. 1955.

1205. **Watson, R., Centrifugal pumps (Forum on Hydraulics),** *Mech. Engng., N.Y.* **77,** 12, 1060–1063, Dec. 1955.

✎1206. **Pounder, C. C., editor, Diesel engine principles and practice,** New York, Philosophical Library, Inc., 1955, xiii + 820 pp. $17.50.

This book was intended as (a) a reference for practicing engineers and (b) a textbook for students. Reviewer believes it should prove especially valuable to a consulting engineer who does not specialize in internal-combustion engines but who is occasionally concerned with their selection and application. It will provide him with an excellent review of fundamentals and will bring him up to date on sound practice. It contains an unusually large amount of engineering experience of a type not found in most textbooks, contributed by a truly impressive array of authors. The contributors being British, emphasis is on British engines, with some discussion of other prominent European designs and a few American.

Reviewer considers that its use as a textbook is rather limited. The price is high for most students. The sections on theory are sound and nicely written but possibly too concise for the usual undergraduate student unless accompanied by an exceptional teacher. Concerning only diesel engines, it is too restricted for the usual American college courses. Under more specialized conditions, however, it should be of considerable utility and a valuable addition to an engineer's library.

Topics included are: Theory of compression-ignition engines, fuel and combustion, fuel-injection systems, scavenge and exhaust systems, theory of exhaust gas turbocharging, exhaust-driven turbochargers, heat exchangers, lubricating oils, starting gear, transmission systems, governors and governor gear, torsional vibration in shafting, balancing of engines, metals used in diesel engines, bearings and bearing metals, crankcase explosions: causes and prevention, vehicle and tractor engines, engines for rail cars and locomotives, air-cooled diesel engines, stationary high-speed engines, engines of moderate power and speed, dual-fuel engines, marine engines, vibration and noise, the testing of diesel engines, diesel engine maintenance.

J. A. Scanlan, USA

1207. **Leiker, M., Turbocharging of two-stroke diesel engines** (in German), *Jahrbuch Schiffbautech. Gesellsch.* **48,** 175–199, 1954.

Article is based on paper read by author before the "Schiffbautechnische Gesellschaft." Principles and practical considerations governing the application of turbocharging to two-stroke engines are described.

Simple theoretical considerations are based on well-known series of volumes by List ["Der Ladungswechsee der Verbrennungskraftmaschine," parts I to III, Springer, 1949/1954] and on a paper by Baumann [*MTZ*, July 1954, pp. 189–199] and describe scope and limitations of process. Concluding part is devoted to description and analysis of various existing engines embodying the principle; it includes detailed assembly drawings, photographs, and performance curves. Remarks concerning important question of piston temperatures are also included.

Article gives a useful review for the benefit of designers and development engineers; particularly, because it is based on the experience obtained in author's firm, the Klöckner Humboldt Deutz AG. J. Kestin, USA

1208. **Wassenaar, H., Injection phenomena in high-speed diesel engines,** *Instn. mech. Engrs.*, Preprint, 16 pp., 1955.

1209. **Vulliamy, N. M. F., Matching a Diesel engine to light road vehicles,** *Instn. mech. Engrs., auto. Div.*, 12 pp., 1955.

Flow and Flight Test Techniques

(See also Revs. 1145, 1146, 1202, 1203)

1210. **Kronauer, R. E., and Grant, H. P., Pressure probe response in fluctuating flow,** *Proc. second U. S. nat. Congr. appl. Mech.*, June 1954; Amer. Soc. mech. Engrs., 1955, 763–770.

Authors analyze the effect of turbulent flow in the probe hole of a pressure-measuring system subjected to fluctuating angularity, velocity, and dynamic pressures such as are encountered in the wake of moving blade machinery.

A theoretical development and tunnel investigation of the magnitude of these effects are presented. J. B. Duke, USA

1211. **Winternitz, F. A. L., Cantilevered pitot cylinder,** *Engineer, Lond.* **199,** 5183, 729–732, May 1955.

The properties of the cantilevered pitot cylinder have been investigated under "free-stream" conditions in a towing tank and in correlated wind-tunnel tests. The effects of probe tip shape, orifice distance from tip, flutter, Reynolds number, and inclined flow have been studied. The results of these experiments are reviewed and an extensive survey is made of the literature on the cantilevered pitot cylinder with particular reference to its use as a static pressure measuring device. From author's summary

1212. **Kritz, J., Ultrasonic flowmeter,** *Instruments and Automation* **28,** 11, 1912–1913, Nov. 1955.

It has long been the goal of the flowmeter designer to produce a flowmeter having no pressure drop and no obstructions to flow, and unaffected by variables such as temperature, pressure, viscosity, gas bubbles, solids and suspension, or position in installation. This new ultrasonic flowmeter approaches the design goal. It uses the change in velocity of propagation of two 10-Mc wave forms to produce a beat frequency (0 to 50 cps) that is proportional only to flow rate of fluid in pipe. Separate transducer produces signal proportional to mass rate.

From author's summary

1213. **Kovacic, E., Two solutions for micromanometer** (in French), *Houille blanche* **10,** 2, 177–181, Mar./Apr. 1955.

Paper describes a micromanometer constructed from ordinary laboratory equipment, i.e., two U tubes and a capillary tube in which an air bubble moves under the action of pressure. Possibility is suggested of using the apparatus with equal efficiency for measurements of both gas and water pressure (up to 0.01 mm). Presentation is made of a second apparatus enabling measurement of small drops in level of liquids and consequently also of gas pressures. The instrument mainly comprises a float, the vertical movements of which are transmitted to a geodetic level (sensitivity: 1 micron). Author mentions particularly the spherical supports which insure a constant load on the float while the air bubble is in motion. From author's summary

1214. **Vágás, I., Measurement of flow of small rivers with salting** (in Hungarian), *Hidrológiai Közlöny* **35,** 5/6, 202–206, May/June 1955.

Paper presents a thorough discussion of the determination of the volume rate of flow of small rivers with salting method. The basic physical or chemical aspects are not discussed; emphasized are the techniques, limitations, and instrumentations. From the principles of continuity of the rate of flow weighed with the salt concentrations, equations are derived for the time needed to introduce the solution, for the amount of the solution to be used, and for the distance between input point and measurement point. The application of these equations requires preliminary measurements.

Note that the paper discusses the use of salt concentration measurements in order to determine the volume rate of flow, and not the so-called salt-velocity method [*Trans. ASME* **45,** p. 285, 1923]. V. G. Szebehely, USA

1215. **Snodgrass, R. B., Flight measurements of aerodynamic heating and boundary layer transition in the Viking 10 nose cone,** *Jet Propulsion* **25,** 12, 701–706, Dec. 1955.

Author presents heat-transfer coefficients obtained over Mach number range from 1.2 to 5.28 on $12^1/_2$ deg semivertex angle cone. Data were obtained for the case where the boundary was laminar, transitional, naturally turbulent, and artificially tripped. Reynolds number range was from 5×10^4 to 10.45×10^6. Reynolds number for natural transition was between 3.5 to 5.5×10^6.

Heat-transfer coefficients obtained for the case of a laminar boundary layer were well correlated by the expression

$$Nu = 0.51 Re^{1/2}$$

where both the Reynolds number and the Nusselt number were local values evaluated at the outer edge of the boundary layer. No Mach number effect was evident.

Plots of the ratio of wall to local free-stream temperature versus local Mach number are given. All data obtained with laminar flow in the boundary layer fell within the Van Driest infinite stability region. It appears that these data were obtained at Reynolds numbers less than about 5.5 million, which is not high enough to be conclusive proof of the validity of the infinite stability region. Tests reported by Jedlicka, J. R., Wilkins, M. E., and Seiff, A. ["Experimental determination of boundary-layer transition on a body of a revolution at $M = 3.5$," *NACA TN* 3342, 1954; AMR **8,** Rev. 1085] have obtained transition well within this region, and very recently Dunn and Lin ["On the stability of the laminar boundary layer in a compressible fluid," *J. aero. Sci.* 22, 7, 455–477, July 1955] have pointed out that for a three-dimensional disturbance no region of infinite stability exists.

G. Goodwin, USA

1216. **Morrow, J. D., and Katz, E., Flight investigation at Mach numbers from 0.6 to 1.7 to determine drag and base pressures on a blunt-trailing-edge airfoil and drag of diamond and circular-arc airfoils at zero lift,** *NACA TN* 3548, 19 pp., Nov. 1955.

Results of an exploratory free-flight investigation at zero lift of several rocket-powered drag-research models having rectangular 6-per-cent-thick wings are presented for a Mach number range of 0.6 to 1.7. Wings of aspect ratio 2.7 having diamond, circular-arc, and blunt-trailing-edge airfoil sections were tested. Pressures were measured on the base of the blunt-trailing-edge airfoil which had a rectangular section with a 40-per-cent-chord beveled leading edge. Although the blunt-trailing-edge airfoil had high drag throughout the Mach number range investigated because of high base suction pressures, it is believed that the data presented can be used in the design of more nearly optimum blunt-base airfoils. Of the airfoils tested, the circular-arc section had lowest drag at high subsonic speeds, and the diamond section had lowest drag at supersonic speeds. From authors' summary

1217. **Morris, G. J., and Lina, L. J., A limited flight investigation of the effect of three-vortex-generator configurations on the effectiveness of a plain flap on an unswept wing,** *NACA TN* 3536, 20 pp., Sept. 1955.

Limited flight tests of a fighter airplane have been conducted to determine the effect of three vortex-generator configurations on the effectiveness of a plain flap. Vortex generators consisting of rectangular airfoils mounted on the upper surface of the airplane wing at the 63-per-cent-chord station produced some increase in airplane lift coefficient at a given angle of attack, no increase in drag with flaps deflected 19°, and no increase in maximum normal-force coefficient. These vortex generators mounted at the 75-per-cent-chord station in another test produced no increase in either airplane lift coefficient or maximum normal-force coefficient. A third generator configuration consisting of larger tapered airfoils mounted at the 63-per-cent-chord station of the airplane wing produced a considerable increase in lift coefficient for a given angle of attack at the 19° flap deflection in a glide but at the expense of increased drag. The effect of these generators was equivalent to a further increase in flap deflection to 27°. No improvement in flap effectiveness was obtained with any of the generators tested for flaps deflected 45°.

The results, therefore, indicate that the vortex-generator configurations tested provided only a little advantage over the use of the flaps alone. Since the vortex generators tested were effective in increasing lift coefficient at moderate flap deflections, they might be used to increase the effectiveness of ailerons.

From authors' summary

1218. **Vogeley, A. W., and Kurbjun, M. C., Measurements of free-space oscillating pressures near a propeller at flight Mach numbers to 0.72,** *NACA TN* 3417, 24 pp., May 1955.

In the course of a short flight program initiated to check the Garrick-Watkins theory [*NACA TN* 3018; AMR **7,** Rev. 1992], a series of measurements at three stations were made of the oscillating pressures near the propeller at flight Mach numbers up to 0.72. These measurements were made at a single radial station and at three axial positions (ahead of, in the plane of, and behind the propeller disk). Despite the limited scope of the tests, agreement with the Garrick-Watkins theory was obtained to the extent that:

(a) The oscillating pressures near the propeller tend to decrease with increase in flight Mach number up to a Mach number of approximately 0.5 and to increase rather rapidly at higher Mach numbers.

(b) The sound-pressure levels of the higher harmonics of the propeller noise increase at a higher rate with increase in flight Mach number than the lower propeller harmonics.

In contradiction to the results found for the propeller studied in *NACA TN* 3018, the oscillating pressures in the plane and ahead of the propeller were found to be higher than those immediately behind the propeller. Factors such as variation in torque and thrust distribution, which could not be investigated in the present test, may account for this contradiction.

From authors' summary

1219. **The Staff of the Supersonics Division, Flight Section, Royal Aircraft Establishment, Flight trials of a rocket-propelled transonic research model: the R.A.E.-Vickers rocket model. Parts I to IV,** *Aero. Res. Counc. Lond. Rep. Mem.* no. 2835, 63 pp., Mar. 1950, published 1954.

From the first conception of a simple model the research vehicle grew to a complex model airplane complete with autopilot, liquid-fuel rocket motor, and radio telemetering equipment, air-launched at 36,000 ft over a ground radar station. The first model, complete with prototype equipment was lost in turbulent air. On the second model launched the rocket motor failed to ignite. There was a period of 12 months' further development of the rocket motor and ignition system, followed by the launch in October 1948 of the third complete model. This model flew satisfactorily and the flight is analyzed in this report.

The model reached a maximum speed of $M = 1.38$. The static-pressure variations on the nose pitot-static-tube agree with availa-

ble information, when allowance is made for the altitude change during flight. There is substantial agreement between measured thrust, longitudinal acceleration, and drag, and the latter is in reasonable agreement with that predicted from wind-tunnel tests. The recorded tailplane angle agrees with that calculated from the instructions given to the autopilot and with the predictions from wind-tunnel tests.

The main body of the report contains a historical review of the project, brief descriptions of the test vehicle and experimental techniques, and the detailed analysis of the final successful flight trial. In a concluding section, the project is discussed critically; it is considered that the work done has shown the experimental method to be an exceedingly difficult one, and that the results it gives do not justify the effort it demands. No further developments are proposed, as alternative transonic research techniques have been developed in the meantime.

In a series of appendixes are given detailed descriptions of the test vehicle and its ancillary equipment, of the development work leading up to the final trial, and of the experimental equipment and techniques. These detailed appendixes will be of interest only to the specialist. From authors' summary

1220. Dosanjh, D. S., Some comments on "A theoretical and experimental study of shock tube flows," *J. aero. Sci.* **22,** 11, 797–799 (Reader's Forum), Nov. 1955.

Conclusive evidence is given to show that when a sufficiently strong shock hits a grid, there appears, besides the reflected and transmitted shocks, an auxiliary shock at the grid. The evidence is drawn from author's published and unpublished works. This disproves Glass-Patterson inference, reached from the study of rotating-drum camera records, that the third entity is a vortex [AMR **8,** Rev. 2486]. M. S. Uberoi, USA

1221. Billington, I. J., An experimental study of one-dimensional refraction of a rarefaction wave at a contact surface, *Univ. Toronto Inst. Aerophys. Rep.* 32, 51 pp. + 69 figs., June 1955.

This is one of a series issued by UTIA covering experimental investigations of simple gas-dynamical interactions. In this report an expansion fan in air interacts with an air-argon or air-helium interface (contact surface). An interesting but unresolved discrepancy was noted in the generation of the expansion fan, which was found to be weaker than predicted by theory, while the shock wave generated at the same time checked the theory. The observed interaction at the interface was in close agreement with theory if the experimental value for the expansion fan was used. The air-argon interface reflects expansion waves and the air-helium interface compression waves.

It is unfortunate that the author did not investigate a helium-argon mixture which would not reflect any wave.

W. Squire, USA

1222. Waldron, H. F., An experimental study of a spiral vortex formed by shock-wave diffraction, *Univ. Toronto Inst. Aerophys. TN* 2, iii + 49 pp., Sept. 1954.

A nonstationary spiral vortex was produced in a shock tube by a normal shock wave striking a flat plate. The opposing velocities produced by the reflected and incident shock wave generate a vortex sheet which rolls up in the form of a spiral. Shadow, schlieren, and light interference photographs are given for incident shock Mach numbers up to 1.54. The density distribution in the pseudostationary plane is presented for both wedge-shaped and blunt plates. Schlieren and light interference photographs are presented for incident Mach numbers up to 2.66. The spiral vortex produced by the blunt plate only was found to occur in a pseudostationary manner. The circulation, calculated from the theory of shock-wave diffraction with vortex separation due to Rott, showed good agreement for the weaker waves.

From author's summary by G. V. R. Rao, USA

1223. MacDermott, W. N., The correction of flexible plate supersonic nozzle contours by influence methods, *J. aero. Sci.* 22, 5, 289–296, May 1955.

A (small) unit deflection of a given jack (pair) causes local changes of slope all along the flexible wall and local changes of flow angle and Mach number inside the tunnel. Application of Puckett's theory [Inst. aero. Sci. Prepr. no. 160, July 1948] for suitable superposition of the above influences from different jacks in order to make flow variations (along the centerline) small had not met with complete success. Author found that beam theory checked satisfactorily with measured wall slopes and that the discrepancy arose between predicted and measured changes in the flow. It is shown how proper usage of experimentally determined jack influences (avoiding the discrepancy) renders Puckett's method very effective (within specified practical limitations).

Of general aerodynamic interest is the experimental finding that *small continuous* changes of wall slope produce centerline peak-pressure changes roughly one third less than predicted by (locally linearized) inviscid theory. According to author, this "damping" effect is absent in theoretical and experimental results on wave reflections from boundary layers. Reviewer notes that, in the present case, pressure gradients reverse sign and that Liepman, et al. [AMR **4,** Rev. 3609] observed damping of peaks in reflections of *relatively larger nearly discontinuous* compression-expansion waves. If this intriguing effect is primarily due to the boundary layer, it should depend on the ratio of some measure of the width of the inviscid pressure peak to the local "upstream-influence distance" (e.g., as defined by Lighthill, *Proc. roy. Soc. Lond.* (*A*) **217,** p. 478, 1953]. M. V. Morkovin, USA

Thermodynamics

(See also Revs. 1021, 1148, 1149, 1150, 1204, 1207, 1209, 1250, 1256, 1262, 1263, 1268, 1269, 1273, 1276, 1280, 1297, 1299, 1300, 1301, 1302, 1303, 1318, 1320, 1321)

1224. Lee, J. F., and Sears, F. W., Thermodynamics, Cambridge (Mass.), Addison-Wesley Publishing Company, Inc., 1955, xiii + 543 pp. $8.50.

There seems little doubt now that the present decade will be known to posterity as "The age of the texts on thermodynamics." The authors have attained the remarkable distinction of producing at such times a text which, amidst the abundant competition, is bound to gain wide acclaim.

As stated in the preface, authors set out "to provide a mature approach to the basic principles of thermodynamics for all engineering and applied-science students, regardless of their ultimate professional objectives. Emphasis is placed on basic principles, rather than on detailed engineering applications involving descriptions of equipment and design techniques, in order to encourage a fuller understanding of thermodynamics as a basic science and to develop an orderly process of reasoning from its fundamentals."

The authors succeeded indeed in accomplishing this ambitious task at a level well suited to most of our undergraduate students, who usually study the subject in their junior year of college. In order to attain an orderly and comprehensive exposition, they had to make, of course, a number of compromises so that the fundamental concepts could be introduced gradually. Consequently, some of their definitions suffer from a lack of clarity and rigor. However, this difficulty is common to all the elementary texts in thermodynamics and, at least to this reviewer, the authors' choices seem in many cases superior to those made in the many comparable books available today.

A good deal of success is due to the judicious selection and organization of the subject matter. Out of a total of fourteen chapters, seven are of general importance, dealing with fundamental principles of thermodynamics, while the remainder is concerned with special topics and applications, such as fluid flow, heat transfer, properties of gas and vapor mixtures, vapor and gas power cycles, refrigeration, and the thermodynamic properties of reactive systems.

The fundamental concepts, concerned primarily with the description of an equilibrium state of a thermodynamic system, are introduced in chap. 1. This is followed, in chap. 2, by a concise and comprehensive discussion of the equations of state for the working substance, and their graphical and tabular representations. The first law is then introduced in chap. 3, following essentially the Caratheodory approach, based on the use of the concept of an adiabatic wall to define internal energy as a state function. Incidentally, authors avoid the term "state function," calling it, instead, "the property of the system," in contrast to the path function. In chap. 4 "Some consequences of the first law" are considered. This includes the derivation of the various relationships between specific heat capacities, the analysis of the "quasi-static adiabatic process," the Carnot cycle and its efficiency, "the energy equation of steady flow," and the simple change of phase. This chapter exemplifies perhaps most distinctly the compromise to which the authors are committed for the sake of an orderly arrangement of the subject matter, since some of these topics (e.g., the specific heat relations, the reversible adiabatic process, and the Carnot cycle) can be presented more clearly and rigorously in conjunction with the second law without the use of the artifice of a quasi-static process. In the opinion of the reviewer, it is especially regrettable that so little attention is given to the salient features of the first law, namely, those concerned with the setting up of energy balances and the proper consideration of idealizations introduced to define the system for this purpose. All this is restricted to a very rudimentary treatment of the steady-flow process. No mention is made of transient state or of multiflow stream systems, which, after all, constitute today the most interesting and prominent technological applications. There is also a slip in terminology involved in the use of the words "the energy equation," in that the same expression is employed for the relationship between internal energy and other state functions, and for the expression of an energy balance.

The exposition of the second law (chap. 5) is based on a distinction made between heat and work reservoirs and the consideration of the directions of energy transfer between them during a process. In the opinion of the reviewer, this leads to a less clear and specific formulation of the law than that based on the concept of cyclically operating systems.

Chap. 6 is devoted to a thorough discussion of the concept of entropy, availability, and irreversibility, starting from the Clausius inequality and concluding with a lucid exposition of the fundamentals of irreversible thermodynamics with a particular application to thermoelectric phenomena.

Topics involving the consideration of both the first and second law are grouped together in chap. 7. This includes the derivation of the various differential relationships among state functions, the Maxwell equations, the Clausius-Clapeyron equation, the salient features of the *u-v-T*-, *s-p-T*, and *h-s-p* thermodynamic surfaces for a perfect ("ideal," according to the authors' vocabulary) gas and for water, and the implications of the two laws concerned with the properties of pure substances.

Chap. 8 gives a comprehensive treatment of the fundamentals of unidimensional gas dynamics. Besides the conventional discussion of isentropic flow, it includes a discussion of the properties of Fanno and Rayleigh lines and the analysis of the isothermal pipe flow of a perfect gas with constant specific heats.

Elements of heat transfer are described briefly in the next chapter. Chap. 10 deals with properties of mixtures, starting with Dalton's law for perfect gas mixtures and concluding with psychrometric calculations. Only elementary, practical aspects of these topics are considered, but, by having them in a single chapter, the student gets a synthetic viewpoint on the whole subject of inert gas and vapor mixtures. The vapor and gas power cycles and the reversed, refrigeration cycle are presented in the conventional manner in the next three chapters, respectively. Worth noting is a short section on the second law analysis of a vapor power plant and the inclusion of such topics as the analysis of an internal-combustion gas turbine, the jet propulsion and the liquefaction of gases. The last chapter contains a brief exposition of the fundamentals of thermochemistry, with quite a thorough discussion of the thermodynamic properties of reactive, perfect gas mixtures and a concise treatment of combustion and dissociation.

The text is accompanied by a good selection of tables and charts on thermodynamic properties of the substance. Worth noting here is the inclusion of an impressive number of numerical examples illustrating the use of steam tables.

Besides the numerical examples worked out in the course of exposition, the book contains an exhaustive selection of interesting problems listed in the usual manner at the end of each chapter.

The text is well written and, in general, easy to read. This is well aided by the excellent graphical illustrations, such as the isometric drawings of the *P-V-T* surfaces and the schematic energy flow diagrams.

An instructor adopting this book as a text for engineering students may do well by supplementing his lectures with demonstrations of equipment, the description of which was purposely omitted by the authors.

The selection, organization, and presentation of the subject matter make the book a valuable asset to current literature.

A. K. Oppenheim, USA

1225. Hodge, J., Cycles and performance estimation (Gas Turbine Series, vol. I), New York, Academic Press, Inc.; London, Butterworths Scientific Publications, 1955, xvi + 329 pp. $9.

Book presents a review of the fundamentals of gas-turbine performance cycle analysis along with a detailed discussion of several possible amplifying assumptions. Numerous combinations of the gas-turbine elements (compressor, burner, turbines, and heat exchanger) for both power output and jet propulsion are discussed, with over 100 pages of curves and graphs showing typical performance variation. Book appears to be best suited as a reference book for the advanced student or engineer.

H. Faught, USA

1226. Guggenheim, E. A., Boltzmann's distribution law, Amsterdam, North-Holland Publishing Co.; New York, Interscience Publishers, Inc., 1955, 61 pp. $1.50.

This book arose out of a discussion in 1947 [*Nature* **159,** p. 626] in which Prof. Guggenheim commented on the high degree of ignorance of theoretical thermodynamics by physicists, chemists, and engineers in general. The fault, he inferred, lay in a lack of appreciation of thermodynamics as such, removed from the dominating and confusing bedfellows of experimental thermometry, calorimetry, and heat transfer. Prof. Guggenheim recommended that students be taught, immediately after learning mechanics, the basic premises of thermodynamics, and the book under review describes such a course. The aim of the book, therefore, is "the cultivation of a thermodynamic outlook" and reviewer feels a more general title such as this would do more justice to the text and attract more readers who could study it with profit.

After a summary of the elements of quantum theory, the significance of Boltzmann's distribution law, quoted as an axiom, in the dependence of the equilibrium properties of matter in bulk on absolute temperature is expounded. Chapters are given on ideal monatomic and diatomic gases, the relationship between free and total energy, simple crystals, equilibrium, phase equilibrium, the dielectric constant of a gas, chemical equilibrium, and, finally, a short chapter on the Fermi-Dirac and Bose-Einstein distributions.

The text is concise to the point of terseness and, in general, formal proofs are not given. In particular, statistical theory is avoided. The result is clear, logical and, though it would be improved, first, by numbering equations and more references back when a formula, derived earlier, is repeated and, second, by the avoidance of the same symbol for temperature and kinetic energy (even in the same equation), the author is to be congratulated on the lucid way so much ground is covered in 61 small pages.

As one who cannot claim to be one of the select band who, to quote Prof. Guggenheim in 1947, "thoroughly understand thermodynamics," reviewer enjoyed and benefited from this book, which he feels fully fulfills the author's intention of making its readers appreciate the extent and value of the subject.

G. G. Thurlow, England

1227. Denbigh, K. G., The principles of chemical equilibrium with applications in chemistry and chemical engineering, New York, Cambridge University Press, 1955, xxi + 491 pp. $7.50.

An advanced textbook on chemical thermodynamics with special emphasis on equilibrium systems. Contents are divided into three parts: The principles of thermodynamics; Reaction and phase equilibria; and Thermodynamics in relation to the existence of molecules. The last part, often not included in thermodynamics texts, is a brief discussion of statistical analogs of entropy and free energy, partition function of a perfect gas, perfect crystals and the third law, regular solutions and adsorption, chemical equilibrium in relation to chemical kinetics. These chapters should be especially useful to the reader who has studied classical thermodynamics and wishes to extend his knowledge.

The text is written from a fundamental point of view but applications are introduced in the problems following most chapters. Answers are included. The style of writing is clear and readable. Equations are presented in an elegant and concise form but should offer no difficulty to readers with the usual undergraduate training.

M. Gerstein, USA

1228. Sherwood, T. K., Continuous-flow reactors—the problem of variable residence times, *Chem. Engng. Prog.* **51,** 7, 303–304, July 1955.

1229. Romer, I. C., Jr., and Cambel, A. B., Analysis of isothermal variable area flow, *Aircr. Engng.* **27,** 322, 396–399, Dec. 1955.

Authors summarize as follows: "In this paper, the isothermal flow of perfect gases is discussed, following the gas dynamic approach of applying the continuity, momentum, and energy equations. Flow functions for isothermal, reversible, one-dimensional flow are derived and these are represented graphically. Isothermal flow in convergent-divergent nozzles is analyzed, and the variation of the derived flow functions is depicted."

For the study of isothermal flow, reviewer finds it much simpler to define an isothermal sonic speed, which is simply $(RT)^{1/2}$ for ideal gas, instead of the usual isentropic one $(kRT)^{1/2}$. Then isothermal flow becomes similar to isentropic flow. For instance, the speed at the throat is always sonic, and, in case of constant-area flow, friction always brings the speed toward sonic independent of the initial speed.

L. S. Dzung, Switerland

1230. Keyes, F. G., Thermal conductivity of gases, *Trans. ASME* **77,** 8, 1395–1396, Nov. 1955.

Author presents new thermal conductivity measurements for argon, krypton, xenon, nitrogen, oxygen, carbon dioxide, and methane over a pressure range up to about 10 atm in the gas phase, and, when possible, in the liquid phase also. The data cover the low temperature range from −186 to 0 C.

S. Gratch, USA

1231. Andresen, E. G., and Urban, H., Two methods for the determination of C_p/C_v (in German), *Feinwerktech.* **59,** 9, 318–322, Sept. 1955.

Authors analyze known method of calculating specific heat ratio from measurement of the period of an oscillating sphere and investigate errors due to finite amplitude. As a substitute, measurement of total oscillating amplitude is suggested. New method is claimed to be inherently more accurate. Experimental results are given.

In spite of the title, methods actually give isentropic exponent, which is equal to specific heat ratio only in case of ideal gases.

L. S. Dzung, Switzerland

1232. Zinkl, R., Effect of flow losses on power cycles (in German), *Brennstoff-Wärme-Kraft* **7,** 8, 350–353, Aug. 1955.

Every power cycle consists of four main processes: compression, addition of heat, expansion, and rejection of heat. For all known cycles (except for the internal-combustion engine), these four processes take place in separate parts of the engine. The losses therefore occur in four different locations and during the intervening transport of energy. Article shows how to calculate (by standard thermodynamics) these losses and their aggregate effect on engine efficiency.

From author's summary by W. Hitschfeld, Canada

1233. Bäckström, M., The Peltier effect—the future way of operating household refrigerators? *Kyltekn. Tidskr.* no. 5, 72–74, 1955.

The use of thermocouples has been suggested previously for refrigeration. The known principles of Peltier cooling are summarized, and the efficiency is computed as a function of thermoelectric power, resistivity, and heat conductivity. Materials are needed which have a thermoelectric power in excess of 200 microvolts/°C and normal Wiedemann-Franz-Lorenz relations. The computations are applied to alloys used by Forsberg [title source, Dec. 1952]. The largest calculated temperature drop is 27.4 C. The efficiency is not as high as that of commercial absorption-type refrigeration. Further development is clearly indicated.

T. Telkes, USA

1234. Kayan, C. F., Refrigerating-plant performance characteristics by electrical-analog analysis, *Trans. ASME* **77,** 4, 543–548, May 1955.

Paper is an extension of author's work on resistance-concept electrical analog for heat-flow systems [cf. AMR **4,** Rev. 4617; *Trans. ASME* **67,** p. 713].

Author considers integrated machine and heat-transfer complex wherein the thermal resistance concept has been extended to condenser and evaporator heat transfer. When added to previous work for compressor performance, a typical vapor cycle machine may be analoged.

The electrical analogy allows predictions of plant performance for a given set of steady-state conditions. A performance plot is obtained by varying the analog inputs. In illustrative example shown, the results are uncorrelated.

The analog's simplicity (actually a voltage divider) is offset by the manipulation required, but this is a small price to pay for the apparent net saving in calculation time.

A. C. Block, USA

1235. **Jordan, G. V., Jr., Separation of immiscible liquids by means of porous membranes,** *Trans. ASME* **77,** 3, 393–400, Apr. 1955.

See AMR **7,** Rev. 2984.

1236. **Mercea, V., and Fodor, E., Study of molecular flow and its application for gas analysis** (in Rumanian), *Acad. Repub. pop. Rom. Comun.* **5,** 7, 1041–1052, 1955.

Authors study the characteristics of bridges comprising two porous plugs and two capillary tubes. They show analytically how a combination of molecular and viscous flow can be used in a null device to analyze mixtures of two gases. An experimental calibration of the method proposed did not give the accuracy of 1% expected by the authors. This is probably due to the sensitivity of the device to temperature. M. A. Santalo, USA

1237. **Mercea, V., and Rozsa, M., Measurement of high temperatures based on the variation of viscosity with temperature** (in Rumanian), *Acad. Repub. pop. Rom. Comun.* **5,** 7, 1041–1046, 1955.

Authors cleverly arrange four capillary tubes in a bridge circuit. A null measuring technique allows determining the temperature of one of the capillaries if the others are at a fixed temperature and the temperature dependence of viscosity of the gas flowing in the capillaries is known. A calibration of the device up to 900 C against a Ni-Cr-Ni thermocouple showed a sensitivity of 2 to 10 C, depending on the flow rate of gas. Authors believe that this apparatus may be used up to 2000 C and with the measuring capillary as far as 30 m from the rest of the capillary bridge. M. A. Santalo, USA

1238. **Van Stein Callenfels, G. W., Measuring high temperatures** (in Dutch, with English summary), *Ingenieur* **67,** 5, 20–27, Feb. 1955.

Author discusses the advantages and disadvantages of several types of radiation pyrometers and thermocouples when measuring high temperatures. Applications are given concerning the measurement of the temperature of liquid steel, the walls of steel furnaces, glowing steel sheets, flames, and hot gases.

From author's summary

1239. **Prince, M. B., Silicon solar energy converters,** *J. appl. Phys.* **26,** 5, 534–540, May 1955.

Theory is given for the design of silicon solar energy converters commonly known as the Bell Solar Battery. Values are given for the various parameters in the design theory. Experimental data are presented and compared with the theoretical relations based on a simple model.

It is found that, with present techniques, units can be made with up to 6% efficiency in the conversion of solar radiant energy to electrical energy. An important factor in obtaining such high efficiencies is the reduction of the series resistance of the cell to as low a value as possible.

From author's summary

1240. **Bowden, S. T., Variation of surface tension and heat of vaporization with temperature,** *J. chem. Phys.* **23,** 12, 2454–2455, Dec. 1955.

1241. **Lin, T. C., and Street, R. E., Effect of variable viscosity and thermal conductivity on high-speed slip flow between concentric cylinders,** *NACA Rep.* 1175, 36 pp., 1954.

See AMR **6,** Rev. 2865.

1242. **Bijl, D., and Pullan, H., A new method for measuring the thermal expansion of solids at low temperatures; the thermal expansion of copper and aluminum and the Gruneisen rule,** *Physica* **23,** 4, 285–298, Apr. 1955.

A description is given of an apparatus for measuring the thermal expansion of solids at low temperatures. This is based on the measurement of the change of capacity of a condenser produced by a change in length of the specimen. Experimental results on the thermal expansion of copper and aluminum are discussed in relation with Gruneisen's rule. This rule is shown to break down at temperatures below about 0.30 K, the expansion becoming smaller than the values predicted by Gruneisen's rule. This deviation can be explained in terms of Born-von Karman's lattice dynamics. From authors' summary

Heat and Mass Transfer

(See also Revs. 972, 1028, 1112, 1113, 1121, 1137, 1149, 1150, 1167, 1175, 1177, 1178, 1200, 1215, 1223, 1224, 1225, 1226, 1228, 1229, 1230, 1234, 1240, 1299, 1300, 1301, 1302, 1303, 1304)

1243. **Vodička, V., Hollow circular cylinder under periodic fluctuations of temperature,** *Appl. sci. Res.* (*A*) **5,** 5, 327–337, 1955.

A complete series solution is presented for the temperature history in an isotropic tube whose inner and outer cylindrical surfaces and two end surfaces are exposed to periodic ambient temperatures of different amplitudes and frequencies. All surface conductances are considered uniform but different for each of the four surfaces.

Author cites no specific example of a physical system to which these general boundary conditions apply.

P. J. Schneider, USA

1244. **Vodička, V., Steady temperature in multilayer bodies,** *Appl. sci. Res.* (*A*) **5,** 5, 321–326, 1955.

Solutions are derived for the steady temperature profile in an infinite slab, an infinite cylinder, and a sphere, each made up of n isotropic layers with specified uniform interface conductances. Conductances of the two free surfaces are different but uniform, and the two different ambient temperatures are also uniform. P. J. Schneider, USA

1245. **Wille, R. L., Cooling of glass molds,** ASME Ann. Meet., Chicago, Ill., Nov. 13–18, 1955. Pap. 55—A-65, 7 pp. + 4 tables, 15 figs., 1955.

Author describes experiments on cooling of glass molds. He finds great increase in efficiency when "spines" are used on surface of mold. An experimental study of the effect of liquid sodium in hollow molds is also made. G. Horvay, USA

1246. **Cooke, J. C., Note on a heat conduction problem,** *Amer. math. Monthly* **62,** 331–334, 1955.

The problem of determining the temperatures $u(r, \theta, t)$ in a wedge initially at temperature $u = 1$, when $u = 0$ on the boundaries $\theta = 0$ and $\theta = \beta$, is used as an illustration of the directness of the method of integral transformations. The solution is ob-

tained in a known form by applying a finite Fourier transformation and a Hankel transformation in succession.
Courtesy of Mathematical Reviews R. V. Churchill, USA

1247. Temkin, A. G., Influence of the integral criterion of form on the process of heat conduction (in Russian), *Zh. tekh. Fiz.* **25,** 497–511, 1955.

A certain criterion of form of bodies is defined as $E_s = S^{1/2}V^{-1/3}$ where S is the area of the surface and V is the volume of a given bounded body. For a cylindrical body with one infinite dimension, a similar criterion is defined as $E_s = pF^{-1/2}$, where p is the perimeter while F is the area of the cross section perpendicular to the axis of the body. The rate of cooling of certain bodies is expressed as a function of these criteria. The object of the work is to give a precise meaning to a general law of cooling which states that the rate of cooling of a given body increases with an increase of the ratio of the area of its surface to the volume of the body.
Courtesy of Mathematical Reviews H. P. Thielman, USA

1248. Temkin, A. G., A theorem on the maximum of a temperature gradient (in Russian), *Zh. tekh. Fiz.* **25,** 534–540, 1955.

This paper is a further development of the ideas presented by the author in previous paper (see preceding review). It is shown that if the surface of a body is increased without a change in the volume of the body, then there takes place an increase of the rate of heat flow from the body simultaneously with a decrease in the specific heat flow through the surface of the body.
Courtesy of Mathematical Reviews H. P. Thielman, USA

1249. Kays, W. M., Numerical solutions for laminar-flow heat transfer in circular tubes, *Trans. ASME* **77,** 8, 1265–1274, Nov. 1955.

Nusselt moduli as a function of the product of the moduli (Reynolds) (Prandtl) (diameter) (length)$^{-1}$ are presented for several velocity distributions and wall thermal boundary conditions for a constant property fluid. The numerical solutions compare favorably with previous analyses and experiment. Several new solutions are presented. M. Tribus, USA

1250. Tribus, M., and Mahlmeister, J. E., Frictional heating of nonisothermal walls *J. aero. Sci.* **22,** 10, p. 726 (Readers' Forum), Oct. 1955.

Readers' Forum note clarifies the correct meaning of the terms "adiabatic wall temperature" and "effective wall temperature" which have been introduced, but not always clearly interpreted, in papers dealing with high-velocity heat transfer, especially on surfaces with varying stream velocity. Useful relations between both parameters are developed from equations describing heat transfer from a fluid with constant properties to a nonisothermal wall. E. R. G. Eckert, USA

1251. Ziebland, H., Heat transfer problems in rocket motors, *J. Brit. interplanetary Soc.* **14,** 5, 249–264, Sept.-Oct. 1955.

1252. Brun, E. A., and Berger, J., The character of the boundary layer in the presence of transpiration through a porous wall (in French), *C. R. Acad. Sci. Paris* **240,** 19, 1853–1855, May 1955.

A "penetration length" L associated with the injected fluid is defined in an analogous manner to the usual von Karman mixing length, $l = Ky$. By assuming that the shearing stress may be expressed in terms of these two lengths, author derives an equation relating them to the skin friction and the boundary-layer thickness. Using experimentally determined values of the two latter parameters, values of K and L are calculated as a function of the ratio of the velocity of the injected gas to that of the primary free-stream velocity. There is apparently a linear dependence of K on the velocity ratio which is independent of the fluids involved. The rate of change of L increases rapidly with increase in the ratio of the gas velocities and also shows strong dependence on the nature of the gases used. Results are based on the two cases of injections of hydrogen into air and then into carbon dioxide.

The results are only applicable to turbulent boundary layers. From the experiments it appears that as soon as the injected gas velocity reaches a critical value (from 1% to 5% of the free-stream velocity) the boundary layer cannot remain laminar.
I. D. V. Faro, USA

1253. Elser, K., Unsteady heat transfer in turbulent gases with adiabatic compression occurring periodically (in German), *Forsch. Geb. Ing.-Wes.* **21,** 3, 65–74, 1955.

Investigators studied one-dimensional unsteady heat transfer, especially heat transfer to the cylinder or piston from the working gas in a diesel engine motored without combustion. The analytical study was based upon an assumed relation (containing arbitrary constants) between the contribution to thermal conductivity made by turbulent motion and the gas temperature, gas density, and distance from the wall. (Earlier investigators had considered, without success, the flow to be purely laminar.) Temperature distributions and heat flows were each expressed as an infinite series of Hankel functions of space multiplied by harmonic functions of time. Analytical results were specialized then to the case of harmonic temperature variations far from the wall. By suitable selections of the constants which were introduced by the assumed relation for the "eddy conductivity," excellent agreement was obtained with experimental data.
E. L. Knuth, USA

1254. Davies, V. C., and Al-Arabi, M., Heat transfer between tubes and a fluid flowing through them with varying degrees of turbulence due to entrance conditions, *Inst. mech. Engrs.*, Preprint, 8 pp., 1955.

Local and average heat-transfer coefficients were determined for water flowing in an electrically heated tube for a Reynolds number range of 5000 to 17,000. The effect of entrance conditions and inlet-end thermal effects were investigated and the results were correlated by dimensionless groups. For tubes of infinite length, the authors' equations for local coefficient of heat transfer give results approximately 23% lower than the usually accepted correlation equations. Critical L/D values are given for five inlet conditions. The head loss due to abnormal turbulence was measured and compared with the increase in heat transfer. Authors believe that the local heat-transfer method for determining heat transfer from tubes to fluids eliminates errors caused by (a) abnormal turbulence, (b) end conduction, and (c) inlet-end thermal effects. R. G. Nevins, USA

1255. Doughty, D. L., and Drake, R. M., Jr., Free convection heat transfer from a horizontal right circular cylinder to freon 12 near the critical state, ASME Ann. Meet., Chicago, Ill., Nov. 13–18, 1955. Pap. 55—A-100, 17 pp. + 7 figs., 1955.

Experimentally obtained heat-transfer coefficients showed a tenfold increase at the fluid critical state. It is demonstrated that heat-transfer coefficients in the superheated vapor region away from the critical state agree to within 15% of the curve recommended for free convection by McAdams.
S. Ostrach, USA

1256. **Bell, S., and Schaaf, S. A., Heat transfer to a cylinder for the free molecule flow of a nonuniform gas,** *Jet Propulsion* 25, 1, 168–169, Apr. 1955.

Theoretical calculations are presented of heat transfer and equilibrium temperature for cylinder of diameter small compared to molecular-mean-free path, in transverse flow of a monatomic gas not in Maxwellian equilibrium. Authors indicate possible application to hot-wire corrections when surveying boundary layers. Paper is an extension of authors' previous paper [AMR **7,** Rev. 2979], where aerodynamic forces were calculated for same situation. A. E. Bryson, Jr., USA

1257. **Pekhovich, A. I., Heat transfer during the motion of fluids along plane walls** (in Russian), *Zh. tekh. Fiz.* **24,** 6, 1020–1021, June 1954.

1258. **Fraser, D., and Baxter, D. C., Reference pressure probes for an orifice-type icing detector,** *Nat. aero. Establ. Canad. Lab. Rep.* LR-129, 8 pp. + 19 figs., Apr. 1955.

Paper describes wind-tunnel tests on an orifice-type icing detector which, when suitably modified and deiced or anti-iced, can be used to give a reference pressure. This is particularly necessary for installations inside engine intakes, where flush-type static holes may be at pressures far different from static at the detector, so that it is necessary that the detector and reference source are close together. Paper gives information on one configuration of reference probe that proved far less sensitive to yaw than all others tested. A. F. W. Langford, Australia

1259. **Dorsch, R. G., Saper, P. G., and Kadow, C. F., Impingement of water droplets on a sphere,** *NACA TN* 3587, 29 pp., Nov. 1955.

1260. **Nagai, S., Kawai, T., and Taniguchi, K., On cooling by a water jet** (in Japanese), *Trans. Japan Soc. mech. Engrs.* **21,** 104, 310–315, 1955.

In experiments of the condensation of steam on metal surfaces, authors often used the method of cooling by a water jet, as was used by Schmidt. But as the data for such experiments are limited, they tried to find the heat transfer in the cooling by a water jet spreading radially on a horizontal flat plate heated by steam. Authors, at first, deal with the problem of the flow of the water jet on the plate and obtain the experimental equations concerning the variation of the velocity, depth, and transition point of the flow, measuring the depth of the flow at many points on the plate. Secondly, using the results of the flow and the distribution of the local heat-transfer coefficient, they find the relations which contain the Reynolds number and the Nusselt number. From authors' summary

1261. **Godson, W. L., The computation of infrared transmission by atmospheric water vapor,** *J. Meteor.* **12,** 3, 272–284, June 1955.

Author considers basic transmission phenomena with the view to obtaining more accurate atmospheric radiation charts. With the assumption of a random spacing of water-vapor absorption lines, the computation of hemispheric radiation for a narrow region of the water-vapor spectrum can be formulated rather simply for the limiting cases of thick layers and thin layers, even for an abitrary atmosphere and spectrum. With the additional assumption of a logarithmic ogive for line intensities, a flux-transmission function can be developed that is dependent on only two parameters and which gives reasonable accuracy over the entire transmission range. This accuracy can be further improved by semiempirical corrections to the two basic parameters.

From author's summary by A. Whillier, South Africa

1262. **Buchberg, H., Electric analogue prediction of the thermal behavior of an inhabitable enclosure,** *Heat. Pip. Air Condit.* **27,** 6, 131–138, June 1955.

The effect of the short-term daily variations in microclimate on an actual small test hut were observed and compared with the values predicted by an electric analog circuit. The analog apparatus is similar in principle to that described by Paschkis in 1942.

The analog circuits included devices to represent the daily variation in air temperature, solar energy absorption, reradiation, and the radiant exchanges within the building.

The agreement of the predicted and observed behavior is not particularly good in many instances. This the author explains in terms of the assumptions used, and commends the method for flexibility and economy of effort. F. C. Hooper, Canada

1263. **Ore, A., Entropy of radiation,** *Phys. Rev.* (2) 98, 4, 887–888, May 1955.

Author compares the recent derivation by Rosen [title source, **96,** p. 555, 1954] of a formula for the flux of entropy of radiation as a function of the spectral specific intensity with other derivations, discussing at the same time various thermodynamical relations valid in the case of a radiation field.

D. ter Haar, England

1264. **Filippov, L. P., On the question of radiant energy transport in a medium** (in Russian), *Izv. Akad. Nauk SSSR, Otd. tekh. Nauk*, no. 1, 155–156, 1955 (translated from Russian by Friedman, M. D., 572 California St., Newtonville, Mass. 4 pp.).

Author considers radiation exchange between two surfaces separated by an absorbing medium and shows that, far from the walls in a strongly absorbing medium (in which case wall effects are negligible), the rate of energy transfer becomes proportional to the temperature gradient in the medium. The proportionality constant, known as the "radiant heat-conduction coefficient," may be computed approximately from known values of the average temperature, the refractive index, and the absorption coefficient. Paper is a brief elaboration of earlier work by Konakov [title source, 1953] and Shorin [title source, 1950 and 1951]. A. Whillier, South Africa

1265. **Kirschbaum, E., Heat transfer in a vertical evaporator tube expressed in dimensionless coefficients** (in German), *Ingenieur* **67,** 22, 39–48, June 1955.

Paper continues work on evaporation previously reported by author [*Chemie-Ing.-Technik* **26,** 25–28, Jan. 1954; ibid. **27,** 248–57, May 1955]. An experimental plant is described, and results of experiments on a 40-mm diam × 4-m vertical tube using sugar and salt solutions are given. The results are expressed in terms of four dimensionless numbers: N_u, over-all heat-transfer coefficient × surface tension divided by thermal conductivity × pressure; R_e, the liquid temperature (at wall) × specific heat divided by latent heat; S, the ratio of the specific gravity to steam divided by 1000; and Z, the ratio of dynamic viscosity of the fluid to water at 100 C and 1 atm.

The relationship found is that

$$N_u = CR_e S^{1/3} Z^{1/3}$$

C is dependent on the apparent height h of liquid in the tube, being 0.236 for $h = 75\%$ and 0.37 for $L = 40\%$.

It is concluded that the results are applicable to other evaporators. Reviewer agrees that paper is valuable in clarifying a complex process. G. G. Thurlow, England

1266. **Knuth, E. L., The mechanics of film cooling—Part I,** *Jet Propulsion* **24,** 6, 359–365, Nov./Dec. 1954.

Attachment of liquid films to the inner wall of a tube and flow stability are studied experimentally under the condition that a high-velocity turbulent gas flow exists in the tube and that the liquid is injected through radial holes in the tube wall. It is concluded that a good coverage of the inner surface by the film can be obtained in a sufficient range by injection through simple radial holes.

The limits between stable and unstable flow of the liquid film were established by visual observation and by mass-transfer measurements. Stable conditions are characterized by the fact that only small ripples are observed on the liquid surface, which are independent of the liquid flow rate, and that no liquid is carried into the gas stream in droplet form. Flow becomes unstable when a certain liquid flow rate is exceeded. Large waves are observed and droplets are torn off the crests. Results are presented in dimensionless parameters.

E. R. G. Eckert, USA

1267. **Knuth, E. L., The mechanics of film cooling—Part II,** *Jet Propulsion* **25,** 1, 16–25, Jan. 1955.

Rannie presented a theory describing heat transfer and friction on a transpiration-cooled wall exposed to turbulent flow. Crocco extended this theory to the case that the coolant reacts with the hot gas stream. A further refinement is presented in the present paper, essentially connected with an extension of Reynolds analogy as applied to the turbulent regime in such a way that energy and momentum transport by the coolant in its flow away from the wall are accounted for (the validity of this analogy has not yet been checked experimentally). Experiments on mass and heat transfer which are also reported did not cover a range sufficiently wide for a check on whether better agreement is obtained with the new or with Crocco's theory.

E. R. G. Eckert, USA

1268. **Rowand, W. H., and Frendberg, A. M., First commercial supercritical pressure steam generator for Philo plant,** ASME Ann. Meet., Chicago, Ill., Nov. 13–18, 1955. Pap. 55—A-135, 10 pp., 1955.

From experience with the pioneer 2500-psi steam power plant of the Twin Branch Plant of the Indiana and Michigan Electric Company on the American Gas and Electric System, installed in the early 1940's, and subsequent knowledge accumulated in the field, another significant advance into pressures above the critical is now being made at the Philo Plant of the Ohio Power Company. This is the 4500-psi, 1150-F two-stage reheat unit developing approximately 125 megawatts—a joint effort of the American Gas and Electric Service Corporation, the General Electric Company, and The Babcock & Wilcox Company.

From authors' summary

1269. **Fiala, S. N., First commercial supercritical pressure steam-electric generating unit for Philo plant,** ASME Ann. Meet., Chicago, Ill., Nov. 13–18, 1955. Pap. 55—A-137, 21 pp. + 8 figs., 1955.

The commercial success of higher pressures, higher temperatures, reheat, larger units, and single-boiler, single-turbine unit designs has given customers of the utility industry cheap electric power. The Philo project reflects efforts to continue this trend by opening up new avenues of approach. The engineering, design, manufacturing, construction, and operating experience on the 120,000-kw steam-electric generating unit operating at 4500 psi, 1150 F initial temperature with double reheat (first, at 1050 F and, second, at 1000 F) should provide the know-how to create units of still greater economy within the next decade.

From author's summary

1270. **Yamagata, K., Hirano, F., Nishikawa, K., and Matsuoka, H., Nucleate boiling of water on the horizontal heating surface,** *Mem. Fac. Engng. Kyushu Univ.* **15,** 1, 97–163, 1955.

Boiling heat transfer was investigated with distilled and tap water at atmospheric pressure. An optical system evaluated temperatures in and thickness of the boundary layer, and bubble formation.

Four bubble types were observed: sphere and bell (simple), precession and tandem (multiple). Bubble formation depends on liquid velocity and turbulence; simple bubbles are formed at lower heat fluxes. Frequency f varies inversely with diameter at break-off d_0, only for spherical bubbles. The heating cycle involves a pausing period, before bubble formation starts, and a generating period, in which the bubble grows. For all types, the generating time was proportional to $d_0^{1/2}$.

The stirring action of the bubbles, which depends also on the number of bubble columns n, controls the flux. The heat-transfer coefficient α is proportional to $(nd_0^3f)^{1/3}$ in all cases. Surface contamination increases n, and hence α. The coefficient α varies with $(\Delta\theta)^2$ and $q^{2/3}$.

Reviewer believes that this work is a significant contribution to our knowledge of boiling heat transfer.

G. M. Ketchum, USA

1271. **Marshall, W. R., Jr., Heat and mass transfer in spray drying,** *Trans. ASME* **77,** 8, 1377–1385, Nov. 1955.

Heat and mass-transfer phenomena to and from droplets during spray drying are discussed. Evaporation from pure liquid drops and drops with solids present, in quiescent and in moving air, is considered. The problem of evaporation at high air temperatures is noted. Times of evaporation and temperatures of evaporating drops are treated and formulas given. An attempt is made to compute the over-all rate of evaporation for a spray of drops, and the time variation in mean diameter of the spray, based on Probert's work.

It appears to be generally true that spray drying produces spherical particles which are more or less hollow, depending on the material and on certain operating variables; solid particles are the exception. Duffie and Marshall suggested several causes for the hollowness in spray-dried materials. The bulk density of spray-dried goods is an important factor, influencing the size and cost of storage bins, the type of containers, shipping cost, and marketing requirements. Bulk density depends also on particle size and size distribution, the temperature of the drying air, feed concentration, feed temperature, and direction of air flow. Counterflow air produces somewhat denser particles than does concurrent flow of air.

The question of air flow in spray driers is a most important aspect of the spray-drying process, which merits considerable further research.

K. J. DeJuhasz, Germany

1272. **Solvasion, K. R., Moisture in transient heat flow,** *Heat. Pip. Air Condit.* **27,** 11, 137–142, Nov. 1955.

Paper deals with experimental results on transient surface heat flow and temperature distribution in homogeneous and composite slabs of building insulation materials with and without the presence of moisture. Two cases were studied: (1) the slab was initially at a uniform temperature, followed by a sudden change of temperature at one surface; (2) the slab initially assumed a steady-state condition with two boundary surfaces kept at different temperatures; then the temperature at the hotter surface was suddenly brought down and maintained at a value identical to that of the other surface. Data were plotted and compared with well-known theoretical solutions for dry homogeneous slabs of constant thermal properties under similar initial and boundary conditions. It was shown that a moderate amount of moisture

present in such materials could substantially increase the rate of surface heat flow and also appreciably modify the temperature distribution under transient conditions. Additional mechanism of heat transmission due to evaporation, vapor flow, and condensation of moisture was mainly responsible for the difference. However, the presence of moisture had only small influence on the steady-state heat flow. B. T. Chao, USA

1273. **Fischer, T., and Schalk, E., Measurement of surface temperature on moving machinery** (in Hungarian), *Mérés és Automatika* **3,** 2, 33–40, Feb. 1955.

After a brief survey of previously employed methods, authors describe their thermistor surface thermometer adapted for use in paper mills. L. S. G. Kovasznay, USA

1274. **Dies, R., Temperature measurements during punching holes into sheet metal** (in German), *Werkstatt u. Betrieb* **88,** 10, 617–620, Oct. 1955.

1275. **Neher, E., Measurements of gas temperatures in high-speed flow** (in German), *Motortech. Z.* **16,** 8, 234–239, Aug. 1955.

1276. **Packer, L. S., and Box, H. C., Vortex-tube free-air thermometry,** ASME Ann. Meet., Chicago, Ill., Nov. 13–18, 1955. Pap. 55—A-22, 9 pp. + 8 figs., 1955.

In an attempt to circumvent the difficulties of measuring ambient air temperature from an airplane, the Ranque-Hilsch or vortex tube has been applied to subsonic free air thermometry. Reliable readings of at least ±1 C accuracy over a wide range of flight conditions were sought for military application. By simulating flight in the laboratory, two prototypes with the desired performance were developed. Limited flight tests confirmed the validity of the laboratory simulation method. It is concluded that a uniflow vortex tube is a successful free-air thermometer, but it is emphasized that several aspects of the application require further study. From authors' summary

Combustion

(See also Revs. 1112, 1225, 1227, 1228, 1251, 1299, 1300, 1301, 1302, 1303)

1277. **Smith, F. T., Theory of the spherical diffusion flame: The effect of atmosphere depletion,** *J. chem. Phys.* **22,** 9, 1605–1609, Sept. 1954.

A mathematical formulation is presented for interpreting data obtained in a spherical diffusion flame (fuel diffusing from a point source radially into an oxidant atmosphere). The basic nonlinear differential equation from which this formulation is derived assumes that the rate of combustion is controlled by one oxidation reaction, which is first order in fuel and first order in air. It is further assumed that temperatures and pressures are sufficiently constant throughout the entire zone of interest so that the reaction rate constant and diffusivity of fuel and air are constant. Convective effects are neglected in the reaction zone. A correction for depletion of the atmospheric reactant in the reaction zone is evaluated, which may be applied to data already available and which indicates that use of a wider range of experimental conditions is permitted. M. Baker, USA

1278. **Schultz-Grunow, F., Flame shapes in tubes or ducts of rectangular cross section** (in German), *Z. Elektrochemie* **58,** 9, 804–808, 1954, Reprint.

Hydrodynamic calculations of flame shape in a tube show that existence of a curved front does not depend on assumption of constant burning velocity over the whole flame surface. [Compare Ball: "A study of a two-dimensional flame," Combustion Report, Harvard, 1951, and review by Gerstein, "Fourth Symposium on Combustion," p. 39, 1953, Williams & Wilkins, Baltimore, Md.] Calculations of flame shapes in ducts of rectangular cross section predict dead spaces, extent of which depends on duct diameter as observed. D. M. Simon, USA

1279. **Berman, K., and Cheney, S. H., Jr., Rocket motor instability studies,** *Jet Propulsion* **25,** 10, 513–518, Oct. 1955.

Additional data of the experimental study of the instability phenomenon with an observation window inserted in the rocket motor chamber or nozzle are presented following two previous reports by the same authors [AMR **5,** Rev. 3221; **6,** Rev. 3554]. In the new information, the effect of chamber length on the prevailing frequency of unstable oscillation should be emphasized. Unstable oscillations with frequency intermediate between the high frequency type (organ-pipe type or screaming) and the low frequency type (or chugging) are reported, and a mechanism of producing instability of this frequency range is advanced. (Reviewer believes that the authors' use of "low frequency instability" for this type is inadequate.) Observations of oscillations in throatless motors and nozzles are of interest.

S.-I Cheng, USA

1280. **Grumer, J., Harris, M. E., and Schultz, H., Flame-stability limits of ethylene, propane, methane, hydrogen and nitrogen mixtures,** *Indust. Engng. Chem.* **47,** 9, 1760–1767, Sept. 1955.

1281. **Anonymous, Organic waste burns wet, produces 2200-psi steam,** *Power Engng.* **59,** 12, p. 63, Dec. 1955.

New process actually burns organic waste under water—either in suspension or solution—and produces excess steam for power or process use. Norwegian plant will be the first big installation. From summary

1282. **Buckland, B. O., and Sanders, D. G., Modified residual fuel for gas turbines,** *Trans. ASME* **77,** 8, 1199–1209, Nov. 1955.

1283. **Grosse, A. V., and Kirshenbaum, A. D., The premixed hydrogen-fluorine flame and its burning velocity,** *J. Amer. chem. Soc.* **77,** 19, 5012–5013, Oct. 1955.

Acoustics

(See also Revs. 1115, 1163, 1166, 1212, 1218)

1284. **Pridmore-Brown, D. C., and Ingard, U., Sound propagation into the shadow zone in a temperature-stratified atmosphere,** *NACA TN* 3494, 57 pp., Oct. 1955.

Authors work out geometric ray relations for refraction of sound in temperature-stratified atmosphere using spherical and directional (dipole, oriented at 45° to horizontal) sources. Normal adiabatic lapse rate causes sound diminution from former but increase from latter up to a horizontal distance of five kilometers.

Relations for sound diffraction into the geometric shadow zone are also developed. Calculations for a 500-cps tone in an atmosphere having a lapse rate of 0.5°C/m show the sound pressure in the diffraction region decreasing 3 db per doubling of distance, plus an additional loss of 78, 58, or 35 db per 1000 ft for ground covers having normal impedances of ρc, 10 ρc, or infinity, respectively.

To test the theory, a two-dimensional sound field was pro-

duced in a ⅝ in. thick air space between two 8 ft × 3 ft parallel steel plates. An effective temperature gradient of 250°C/m was developed. The sound field from pulses of high frequency sound (2700–10,400 cps) was explored with probe tube microphone and found to agree rather well with predicted values.

W. W. Soroka, USA

1285. **Awatani, J., Studies on acoustic radiation pressure I. General considerations; II. Radiation pressure on a circular disk,** *J. acoust. Soc. Amer.* **27,** 2, 278–286, Mar. 1955.

I. For irrotational motion, a perturbation procedure applied to the Euler hydrodynamical equations gives the excess pressure to the second order and its time average. The tensor character of the radiation pressure on nonstiff and stiff movable surfaces is analyzed.

II. The theory of the first paper is used to analyze the pressure on a thin disk (regarded as the limit of an oblate spheroid) which lies in a plane perpendicular to the direction of propagation of a plane progressive or standing wave. Numerical calculations are given and graphs are presented which show the pressure as a function of the ratio of disk circumference to sound wave length for very small or very large disks of various relative weights.

H. D. Block, USA

1286. **Rhian, E., An exact method for determining the directivity index of a general three-dimensional array,** *J. acoust. Soc. Amer.* **26,** 5, 704–706, Sept. 1954.

An exact method for determining the directivity index of a general three-dimensional array with phased elements is described. The expression for the reciprocal of the directivity factor is shown to be a sum of terms which are simple functions of the sensitivity, phasing, and location of the elements of the array. As an example, the method is applied to a sixteen-element plane array.

From author's summary by G. S. Verma, India

1287. **Ingard, U., Transmission of sound through a stretched membrane,** *J. acoust. Soc. Amer.* **26,** 1, 99–100, Jan. 1954.

The problem of sound transmission through a membrane stretched across a duct is analyzed rigorously. The integral equation for the velocity distribution of the membrane is set up and studied in the special case of a circular cylindrical tube. Equivalent circuits for the membrane are shown for the frequencies around the resonances and the antiresonances of the membrane. High transmission loss is commonly associated with a large mass, but it is clear that it can also be obtained with very little mass if stiffness, rather than mass, provides the high impedance.

From author's summary

1288. **Parkin, P. H., and Scholes, W. E., Air-to-ground sound propagation,** *J. acoust. Soc. Amer.* **26,** 6, 1021–1023, Nov. 1954.

The attenuation of sound in air, in the vertical direction, has been measured on six occasions using an aircraft flying at various heights over a microphone at ground level. It was found that there was always negligible attenuation at frequencies below 1000 cps even though the air was turbulent; at higher frequencies the attenuation was found to be of the same order as the Knudsen-Kneser results for attenuation due to molecular absorption.

From authors' summary

1289. **Junger, M. C., and Rosato, F. J., The propagation of elastic waves in thin-walled cylindrical shells,** *J. acoust. Soc. Amer.* **26,** 5, 709–713, Sept. 1954.

The theory proposed by authors takes account of flexural stresses. Previous work was based on the membrane theory and predicted a dead frequency region in which no propagation was possible. Present theory agrees with the experiments of Giebe and Blechschmidt [*Ann. Physik* **18,** p. 417 and p. 457, 1933] in the low-frequency part of the first mode and the high-frequency part of the second mode. No experimental results are available to confirm the minimum predicted in the first mode by present theory.

Applications of these results are to transducer theory and to theory of sound insulation. J. M. Jackson, Scotland

1290. **Brekhovskikh, L. M., Diffraction of waves from an irregular surface. I. General theory; II. Applications of the theory** (in Russian), *Zh. eksp. teor. Fiz.* **23,** 3 (9), 275–314, 1952 (translated from Russian by M. D. Friedman, 572 California St., Newtonville, Mass. Part I, 27 pp; part II, 21 pp.)

The problem of determining the diffraction of sound and electromagnetic waves from irregular surfaces is very difficult and, so far, an exact solution has not been found. The first attempt was made by Rayleigh, who found an approximate solution for a sinusoidal surface with small amplitudes. Author presents an approximate method of solution for surfaces having radius of curvature at all points sufficiently large in comparison with the wave length, whereby the character of the irregularity and the physical properties of the medium bounded by the irregular surface can be arbitrary.

Chap. 1 reviews previous research (Andronov, Leontovich, Antokol'skiĭ, Twersky, Ornstein). Chap. 2 contains mathematical solution of the diffraction of sound waves by using Green's theorem and Kirchhoff's assumption. Chap. 3 deals with similar problem of electromagnetic waves. In chap. 4, the principle of the conservation of energy is checked, and chap. 5 discusses the limits of applicability of the author's method. Part II presents the application of the general theory in a series of cases of diffraction by wavy surfaces of different form, as uneven areas of bounded dimensions and sinusoidal surfaces, accompanied by graphs showing the characteristic directivities of the diffracted wave for different ratios of waviness amplitude and the wave length of radiation. J. J. Polivka, USA

1291. **Kurtz, G., Tamm, K., and Vogel, S., Model studies on the damping of flexural waves at corners** (in German), *Acustica* **5,** 4, 223–233, 1955.

Two square plexiglas bars, each 3 × 3 × 400 cm, were joined at right angles by three methods: a rigid cemented joint; a pad of lossy elastomer; and a hinge. Flexural waves were excited in one bar, and suitable vibration pickups detected the reflected and transmitted flexural and extensional waves. The bars were terminated in sand boxes to avoid reflections from their free ends. For the rigid joint the amount of transmitted extensional wave increased with frequency, whereas with an elastic connection the transmission sometimes decreased for thick layers of the connecting pad. Hinged joints behaved in an intermediate fashion. Agreement with the theory of Cremer [title source **3,** 317, 1953] varied from fair to excellent. V. Salmon, USA

1292. **Fox, F. E., and Wallace, W. A., Absorption of finite amplitude sound waves,** *J. acoust. Soc. Amer.* **27,** 6, 994–1006, Nov. 1954.

The absorption coefficient in carbon tetrachloride and in water is measured for intensities as high as 7 watts/cm² at frequencies of 5 and 10 mc, respectively; the coefficient increases by a factor of 5 for water and of 2 for CCl_4. The increase is attributed to the wave distortion at finite amplitudes. A theory is developed in which the medium is treated as a transmission line with non-

linear impedance elements; it is believed to hold when the ratio of particle velocity to the local sound velocity is finite but still a small quantity compared with unity. Within this range the theory yields a qualitative as well as a quantitative description of finite amplitude waves in dissipative media. Agreement between theory and experiment is reached.

F. E. Borgnis, USA

1293. **Curle, N., The influence of solid boundaries upon aerodynamic sound,** *Proc. roy. Soc. Lond.* (*A*) **231,** 1187, 505–513, Sept. 1955.

In Lighthill's theory of aerodynamic sound [AMR **6,** Rev. 651; **8,** Rev. 851], only the infinite space without obstacles and boundaries is considered. The present paper extends the theory to include also the effects of rigid boundaries.

This is done in a way similar to Lighthill's original theory. First, the Navier-Stokes equations are reduced to an inhomogeneous wave equation (as in original theory). Second, a general solution of this inhomogeneous wave equation is written as the sum of a volume and a surface integral. While the volume integral is the same as in Lighthill's theory (equivalent to acoustic quadrupole radiation), the surface integral, which is extended over the rigid surfaces, is the modification necessitated by the presence of rigid boundaries. It is shown that the sound due to the surface integral is equivalent to the sound generated by a distribution of dipoles, representing the fluctuating forces with which the boundaries act upon the fluid.

A dimensional analysis is finally applied in order to estimate the relative magnitudes of the intensities of the dipole part (surface integral) and the quadrupole part (volume integral) of the sound field. H. L. Oestreicher, USA

1294. **Connolly, W., and Fox, F. E., Ultrasonic cavitation thresholds in water,** *J. acoust. Soc. Amer.* **26,** 5, 843–848, Sept. 1954.

The temperature dependence of the minimum sound pressure needed to produce cavitation in gassy water has been measured over a range of 0 to 30 C. Both plane progressive and focused waves of frequency 1 megacycle/sec were used. The cavitation pressure threshold P_c is not a linear function of temperature, and increases by a factor of 2.5 between 30 and 0 C. About 50% higher sound-pressure amplitude is needed to initiate cavitation than to maintain it. The relation of P_c to the reciprocal temperature, to viscosity, and to the degree of undersaturation is discussed. From authors' summary

1295. **Truell, R., Ultrasonic attenuation measurements for study of the engineering properties of materials,** ASME Ann. Meet., Chicago, Ill., Nov. 13–18, 1955. Pap. 55–8-17, 7 pp., 1955.

It is the purpose of this paper to discuss a relatively new method of studying the physical properties of materials. It is a method which is being used for fundamental work in the physics of solids, and it has been of interest to a few physicists for some time. It can be used in metallurgy and in quite a few engineering applications of both fundamental value and of immediate practical value, including a number of quality-control applications; it is to these possible applications that most of this paper is directed. The method is sufficiently new so that the results and interpretation of the results are still in the early stages of development, nevertheless many of the fundamental features are clear; it is a method about which you will hear more.

From author's summary

1296. **Towle, D. M., and Lindsay, R. B., Absorption and velocity of ultrasonic waves of finite amplitude in liquids,** *J. acoust. Soc. Amer.* **27,** 3, 530–533, May 1955.

Paper reports the results of measurements of the attenuation and velocity of ultrasonic waves in various liquid media as a function of the intensity level at the detector of the radiation. The attenuation in distilled water and dilute solutions of acetic acid and sodium acetate is found to increase almost linearly with the acoustic excess pressure amplitude in the range from 2 to 7 atm for frequencies of 4, 5, 7, and 9 megacycles/sec. The attenuation in glycerine shows a similar increase when correction is made for the unavoidable rise in temperature of the medium. The rate of increase is found to be practically independent of frequency in the range employed, thus disagreeing with the prediction of R. D. Fay's theory of the attenuation of high-amplitude plane waves. No change of velocity with source intensity has been observed. From authors' summary

1297. **Gabrielli, I., and Verdini, L., On ultrasonic velocity measurements in liquids** (in Italian), *Ric. sci.* **25,** 5, 1125–1131, May 1955.

Description is given of a method concerning ultrasound velocity measurements in liquids by use of pulsed waves, the transit time of which is kept constant. The method is particularly suitable for measurements of velocity as a function of temperature.

Measurements were carried out in benzene, from 18 C to the boiling point, and in palmitic acid, from 95 C to 55 C, i.e., including the undercooled state. From authors' summary

1298. **Murdoch, A., Jr., Ultrasonics, how it works and what it does,** *Amer. Machinist* **100,** 1, 97–104, Jan. 1956.

Ballistics, Detonics (Explosions)

(See also Revs. 1152, 1251, 1279)

1299. **Pendray, G. E., The first quarter century of the American Rocket Society,** *Jet Propulsion* **25,** 11, 586–593, Nov. 1955.

1300. **Seifert, H. S., Twenty-five years of rocket development,** *Jet Propulsion* **25,** 11, 594–603, 632–633, Nov. 1955.

1301. **Avery, W. H., Twenty-five years of ramjet development,** *Jet Propulsion* **25,** 11, 604–614, Nov. 1955.

1302. **Sutton, G. P., History, problems, and status of guided missiles,** *Jet Propulsion* **25,** 11, 615–622, Nov. 1955.

1303. **Rosen, M. W., Twenty-five years of progress toward space flight,** *Jet Propulsion* **25,** 11, 623–626, Nov. 1955.

Soil Mechanics, Seepage

(See also Revs. 1136, 1140)

1304. **Rao, K. S., and Ramacharlus, P. T., Improving the trafficability of soils by heat treatment,** *J. sci. indust. Res., India* **14,** 10, 474–479, Oct. 1955.

A number of experiments performed by the authors on Gangetic alluvial soil of Delhi indicated that the clay percentage decreased continuously as the soil was heated up to 600 C. At the same time, the porosity increased up to 1000 C, and the PF of inflexion point decreased, indicating particle aggregation. Heat-

ing decreased the permeability up to 60 C and then increased it up to 650 C. The liquid and plastic limits, as well as the plasticity index, decreased with heat treatment, and the shear strength as determined by the vane method increased with heat treatment above 360 C to five times the original value.

Authors conclude from their experiments that strength, and hence trafficability, of most soils can be greatly improved by heat treatment.

One of the consequences of heating organic soils to the temperatures indicated is the oxidation of the organic material. Some plastic soils derive all their plasticity from their organic content and contain no clay at all. The reduction of the organic content in such a soil would have essentially the same effects on the soil properties as those described by the authors.

E. Vey, USA

1305. Káraldi, G., and Török, L., Applicablity of the seepage factor (in Hungarian), *Hidrológiai Közlöny* **35,** 5/6, 195–201, May/June, 1955.

Considerations on the range of validity of Darcy's law, which theoretically never applies to seepage problems. At greater velocities in coarse soils, an expression of second degree gives more reliable results; in soils with fine grains (silt, clay), the effect of molecular forces (microseepage) has to be considered; the problem leads to the mechanics of viscoplastic fluids. In seepage problems, the Bernouilli equation has to be used with consideration of the terms of losses. In pumping tests, the results often display deviations from Darcy's law; in most cases, this is caused by inhomogeneity of soil or lack of permanent seepage.

Á. Kézdi, Hungary

1306. Capper, P. L., An elementary introduction to soil mechanics, *Engineering* **180,** 4676, 348–350, Sept. 1955.

1307. Toms, A. H., Soil mechanics in railway civil engineering, *Engineering* **180,** 4677, 384–388, Sept. 1955.

Micromeritics

(See also Revs. 1140, 1165, 1305)

1308. Kraemer, H. F., and Johnstone, H. F., Collection of aerosol particles in presence of electrostatic fields, *Indust. Engng. Chem.* **47,** 12, 2426–2434, Dec. 1955.

Paper presents a general theoretical solution and experimental verification for the deposition of aerosol particles from a moving stream on spherical surfaces and an introductory study for the deposition on cylinders. The various types of electrostatic forces, including Coulombic forces, space-charge effects, and forces of induced charges, that act on aerosol particles, are discussed. The differential equations that describe the path of the particles toward a spherical collector were solved numerically by the ILLIAC electronic digital computer. Experimental measurements of aerosol deposition were found to agree fairly well with the theory. As a result of the investigation, two new types of dust-collection equipment are proposed.

From authors' summary by G. D. S. MacLellan, England

1309. Marks, C. H., Broadley, P. R., and Yellott, J. I., Flow characteristics of aerated crushed coal, ASME Ann. Meet., Chicago, Ill., Nov. 13–18, 1955. Pap. 55—A-118, 9 pp., 1955.

When air is passed at low velocity through a bed of crushed coal, significant changes take place in the flow characteristics of the coal. Most important of these changes are the reduction in the angle of repose from about 50° to as low as 2°, and a major increase in rate of coal flow from the bed. The bed surface rises and becomes horizontal, while its bulk density decreases. All of these effects become more marked as the minus 50 mesh fraction increases. The aerating velocity required to bring about these results with dry crushed coal is so low that carryover of fines from the bed is negligible.

This paper presents the results of studies carried out by Bituminous Coal Research, Inc., to determine the effect of varying aerating velocities upon the flow characteristics of coals of varying size, consistency, and moisture content. The application of the aeration process to the discharge of crushed coal from flat-bottomed bunkers is discussed, and criteria are established whereby the flow characteristics of crushed coal can be predicted accurately when the size and moisture content are known.

From authors' summary

Geophysics, Meteorology, Oceanography

(See also Rev. 1264)

1310. Symposium on modern concepts in meteorology, April 27, 1955, *Proc. nat. Acad. Sci. Wash.* **41,** 11, 797–819, Nov. 1955.

On April 27, 1955, this symposium was held at the National Academy of Science, Washington, D.C., at which the reviewer was fortunate to be present. The first paper, by Dr. J. G. Charney, who is the pioneer in the field of numerical weather prediction, described the historical background of numerical methods in weather prediction.

In the second paper, Jerome Namias talked generally about the basic concept of his technique on the objective method in extended weather prediction. Next, Dr. Thomas F. Malone read his original paper on the objective weather prediction after the method by Wadsworth and Bryan [U.S. Air Force Air Weather Service Tech. Rep. 105-38, 1948], and the results, while not spectacular, indicate a certain amount of usefulness. Lastly, Prof. Sverre Petterssen discussed the effects of artificial nucleation to modify the large-scale systems of the atmosphere to test Langmuir's hypothesis and concluded that it may prove unprofitable to explore means of determining such secondary effects of modification at present. H. Arakawa, Japan

1311. Charney, J., The use of primitive equations of motion in numerical prediction, *Tellus* **7,** 1, 22–26, Feb. 1955.

Charney questions the use of the quasi-geostrophic equations of motion in numerical forecasting, since his experience shows forecasting errors attributable to the geostrophic approximation. He suggests use of a "balance equation" which, assuming only small horizontal divergences and vertical accelerations, turns out to be a Monge-Ampere-type equation in terms of a stream function, the Coriolis parameter, and the geopotential. This equation, together with the hydrostatic, vorticity, physical (energy), and hydrostatic equations, determines the motion. A direct solution of the system of equations has been accomplished only for a barotropic atmosphere. Attempts are being made to use this system of equations in forecasting (see following review).

R. C. Staley, USA

1312. Bolin, B., Numerical forecasting with the barotropic model, *Tellus* **7,** 1, 27–49, Feb. 1955.

Testing and comparison in Sweden of 500 mb 24-, 48-, and 72-hr forecasts made by conventional extrapolation, graphical solution of the barotropic vorticity equation (Fjørtoft), and numerical methods applied to a barotropic atmosphere (using the computer BESK) show computer results slightly superior for large-

scale systems. Failures are apparent where baroclinity is marked (east coast of N. America); results are most successful where barotropic conditions are best met. Bolin discusses "balance equation" (see preceding review) and describes how the system of equations can be used in numerical forecasting. Forecasts using this system of equations are being made now (1955) in Sweden. Results are not yet available.

R. C. Staley, USA

1313. **Skumanich, A., On thermal convection in a polytropic atmosphere,** *Astrophys. J.* **121,** 408–417, 1955.

A plane parallel polytropic atmosphere in which the pressure P is proportional to ρ^{Γ}(where ρ is the density) in equilibrium under a constant acceleration of gravity is considered. If the ratio of the specific heats of the gas is γ, then thermal stability of the atmosphere requires that $\gamma > \Gamma$. If $\gamma < \Gamma$, then the atmosphere is unstable and a measure of the degree of unstability is given by $\epsilon = (1 - \gamma/\Gamma)/(\gamma - 1)$. For $\epsilon > 0$, the amplitude of any disturbance in the horizontal plane will increase exponentially with time. In this paper the characteristic-value problem for determining the e-folding time for a disturbance characterized by a wave number k is formulated and solved. It is shown that the instability increases indefinitely as $k \to \infty$; this is in sharp contrast to a homogeneous atmosphere [discussed by Rayleigh, Scientific papers, 6, p. 432, Cambridge, 1920] for which the e-folding time tends to a limiting value as $k \to \infty$. Solutions obtained by numerical integrations for the case $\epsilon = 0.125$ are tabulated and illustrated.

Courtesy of Mathematical Reviews S. Chandrasekhar, USA

1314. **White, J. E., and Angona, F. A., Elastic wave velocities in laminated media,** *J. acoust. Soc. Amer.* **27,** 2, 310–317, Mar. 1955.

This paper discusses elastic wave velocities in a laminated medium, where the thickness of lamination is small compared with a wave length. Restricting the discussion to a mixture of two materials and to waves traveling either normal or parallel to the laminations, authors present curves which show how the various elastic wave velocities vary with composition of the mixture. Though problem has been drastically idealized, the results should be useful to geophysicists dealing with the interpretation of elastic wave velocities in the surface layers of the earth.

J. M. Jackson, Scotland

1315. **Schuhmann, R., Jr., Application of Gibbs-Duhem equations to ternary systems,** *Acta Metallurgica* **3,** 3, 219–226, May 1955.

A new method is presented for calculating activities, activity coefficients, and other partial molal properties for two components of a ternary system from experimental measurements of this property for the third component. A quantitative relation is derived between tangent intercepts of isoactivity curves for the various components, and this relation is the basis of a graphical procedure of constructing isoactivity curves. The derived relations are used to calculate activities of SiO_2, FeO, and O in ternary iron silicate slags. From author's summary

Lubrication; Bearings; Wear

(See also Rev. 994)

1316. **Lippschutz, H.-W., Journal bearing calculation particularly for refrigeration compressors** (in German), *Technik* 10, 5, 315–318, May 1955.

After short preliminary remarks regarding principles of hydrodynamic theory of lubrication as applied to journal bearing design, author discusses properties of Freon-lubricating-oil mixtures. Several graphs present relationships of pressure and of viscosity versus concentrations of Freon in lube oil at temperatures ranging from 10 C to 70 C.

An example of calculating the performance of a bearing (D = 55 mm and L = 40 mm) used in a refrigeration compressor is given. Considerations of different methods of cooling and heating the oil, of bearing geometry and clearance are indicated. A nomogram prepared by the author supplements the four-page article. L. M. Tichvinsky, USA

1317. **Shawki, G. S. A., Journal-bearing performance for combinations of steady, fundamental, and low-amplitude harmonic components of load,** ASME-ASLE Lubrication Conf., Indianapolis, Ind., Oct. 10–12, 1955. Pap. no. 55—LUB-15, 8 pp. + 8 figs., 1955.

Paper presents the results of an experimental study of the effect, on journal-bearing performance, of superposing the low-amplitude harmonic to fundamental and steady components of a vertical cyclic bearing load of the form

$$P = P_0 + P_1 \sin(\omega_1 t) + P_n \sin(n\omega_1 t + \psi)$$

Amplitude ratio values (P_n/P_1) of between about 0.3 and 0.4 and frequency ratio values (n) of 2, 3, and 4 are considered. Test results exhibit a bearing performance somewhat similar to that obtained with sinusoidally alternating and fluctuating loads with critical changes in performance, at (ω_1/ω) (ratio of the rate of load application to that of Journal rotation) slightly less than 0.5, of a character mainly dependent on the ratio (P_1/P_0). The striking phenomenon encountered in the tests, however, is the appearance of secondary critical changes in the performance at submultiples of the one-half speed ratio, namely at (ω_1/ω) slightly less than 0.25, 0.167, and 0.125 for second, third, and fourth superposed harmonic components of load. An explanation of this behavior is suggested. Further work on the subject is proceeding. From author's summary

1318. **Sorem, S. S., and Cattaneo, A. G., High-temperature bearing operation in the absence of liquid lubricants,** ASME advance paper no. 55—LUB-17, 1955.

Attempts were made to operate single-row, deep-groove, steel-cage ball bearings at 10,000 rpm and 600 F with a radial load of about 30 lb in the absence of any liquid lubricant. Examination of these bearings after short periods of operation indicated that the abrasive effect of metal oxides formed at elevated temperatures played a major role in their destruction. The removal of oxygen from the environment of the bearing eliminated most of the abrasive wear and permitted a substantial extension of bearing life. Experimentally blanketing the running bearing with an inert gas effectively reduced oxide formation, but the most attractive solution to this problem appeared to be the use of a reducing atmosphere of air and hydrocarbon vapor. The addition of sufficient jet-engine fuel (JP-4) to the bearing housing to maintain an air-fuel ratio in the range of 7 to 10 in the bearing surrounding atmosphere was used in much of the subsequent work. Having minimized the contribution of oxidation to the failure mechanisms encountered with dry-running bearings, scuffing, particularly between the rolling elements and their cage, appeared as the next most destructive mechanism. For the prevention of scuffing, the application of conventional extreme pressure films or boundary-lubrication agents by the use of vapor phase additives or by bearing pretreatment has been investigated. Bearings pretreated with sulphur have subsequently been operated with a reducing vapor blanket up to 60 hr at 10,000 rpm and 600 F without appreciable damage to the rolling and sliding surfaces. From authors' summary

1319. **Borsoff, V. N., and Wagner, C. D., Studies of formation and behavior of an extreme pressure film,** ASME-ASLE Lubrication Conf., Indianapolis, Ind., Oct. 10–12, 1955. Pap. no. 55—LUB-25, 12 pp. + 20 figs., 1955.

Gears lubricated with a mineral oil compounded with dibenzyl disulfide containing radioactive sulfur, S^{35}, were operated under controlled conditions. The formation and behavior of the resultant sulfur-containing film on the load-bearing surfaces were studied, using the β-particles from the sulfur as the means of detection of the film and measurement of its thickness.

The thickness of the extreme-pressure film increased with load, but was not affected by duration of running, which suggests that an appropriate steady-state thickness of extreme-pressure film was established for each operating condition. With respect to the tooth operating profile, the minimum thickness of extreme-pressure film occurred at the pitch circle, and it gradually increased toward the addendum and the dedendum. These observations suggest that the temperature existing under the actual gear contact is controlling in the formation of an extreme-pressure film. The maximum thickness of the film observed in this series of experiments was 0.2×10^{-6} inch, which is smaller than the average height of projecting asperities of a surface finished to 20 microinches. From authors' summary

1320. **Hartung, H. A., Prediction of the viscosity of liquid lubricants under pressure,** ASME-ASLE Lubrication Conf., Indianapalis, Ind., Oct. 10–12, 1955. Pap. no. 55—LUB-18, 5 pp. + 8 figs., 1955.

A method is proposed for predicting the pressure viscosity isotherms of liquid lubricants at 100 and 210 F up to 100,000 psi. The method is based on graphical correlation of data from the ASME Pressure Viscosity Report, and in most cases, reproduces those data within about 20%. Data from other sources check within this range as well. The method loses accuracy for low-viscosity oils (less than about 4 centistokes at 210 F), particularly if they have very high-temperature coefficients of viscosity (less than −100 VI). The method is suitable for pure hydrocarbons, normal petroleum fractions, polymer-blended oils, and commercial lubricants. Data required to make the prediction are atmospheric pressure densities and viscosities at 100 and 210 F. From author's summary

1321. **Dow, R. B., The effects of pressure and temperature on the viscosity of lubricants—Part II, Application of Vogel's equation,** ASME-ASLE Lubrication Conf., Indianapolis, Ind., Oct. 10–12, 1955. Pap. no. 55—LUB-19, 5 pp. + 2 tabs. + 2 figs., 1955.

See AMR 8, Rev. 2583.

1322. **Feng, I.-M., Analysis of the effect of various factors, on metal transfer and wear between specimen pairs of same metal and same shape. I. The basic scheme of formulation of metal transfer and wear; II. Effect of the surrounding atmosphere,** *J. appl. Phys.* **26,** 1, 24–32, Jan. 1955.

Author proposes equations for metal transfer and wear as functions of potential amount of metal transfer and mechanical, thermal, and adhesion factors of chance of metal transfer. Resoftening and back transfer are taken into account. Effects of physically adsorbed and chemical compound surface layers on metal transfer and wear, and how they are affected by temperature, gas pressure, and time of exposure are discussed.

Reviewer believes that author's equations, while qualitative, constitute an excellent first approach to a very complex problem. W. J. Anderson, USA

1323. **Anonymous, Bearings, lubricants, and lubrication,** *Mech. Engng.* **77,** 9, 789–801, Sept. 1955.

Marine Engineering Problems

(See also Rev. 1072)

1324. **Jaeger, H. E., Approximate calculation of rudder torque and rudder pressures,** *Intern. Shipbldg. Progr.* **2,** 10, 243–257, 1955.

This article, which appeared in English in 1955, was originally presented in 1952 at the Association Technique Maritime et Aéronautique in Paris. It deals with a method of estimating rudder torque of various types of rudders.

Author has reviewed existing analytical and empirical methods of approximating rudder torque and suggests approximation to bring them into conformity with expectations, particularly for large rotor angles. He concludes by giving several examples of the method that he recommends, and points out that further work of a scientific nature is needed on this subject. The article is particularly valuable in summarizing the known knowledge on this subject and includes a good bibliography. It obviously is not the final answer, but should be of material assistance to rudder designers. W. E. Hammond, USA

1325. **Sasajima, H., and Yoshida, E., Frictional resistance of wavy roughened surface,** *Intern. Shipbldg. Progr.* **2,** 13, 441–450, 1955.

The frictional resistances of a circular pipe and flat plate with wavy roughness are calculated by the authors' modified theory of momentum transfer. Comparison with experiments shows some discrepancy. Assumption in the authors' theory and interpretation of the loss of velocity due to the roughness must be verified by experiments. Reviewer's calculation shows that the frictional resistance increases by a constant with roughness and the constant varies with Reynolds number. M. Kataoka, Japan

1326. **Moiseev, N. M., Dynamics of a vessel loaded with liquid cargo** (in Russian), *Izv. Akad. Nauk SSSR Otd. tekh. Nauk* no. 7, 27–45, July 1954.

This is the third paper of the author in the field of ship stability with a liquid cargo. He claims that the commonly used method, which considers a ship with a liquid cargo and free surface of the liquid as a ship with solid load and correspondingly changed metacentric height, is not correct. For analysis, he uses "quasistationery hydrodynamics" where forces and moments on the ship are subjected to certain restrictions and simplifications.

Assuming that the free surface of the liquid with infinite degrees of freedom has finite but a large number of degrees of freedom, he analyzes the rolling of the ship, the action of the rocking (rolling) moment, the reaction due to horizontal impact, and rolling with large angles.

The article concludes with an analysis of vertical ship oscillations with interesting results that any amplitude and frequency of the ship builds up oscillatory movements of the free liquid. A. Nasvytis, USA

1327. **De Groot, D., Resistance and propulsion of motorboats,** *Inter. Shipbldg. Progr.* **2,** 6, 61–77, 1955.